

Adverse Childhood Environment and Self-Reported Sleep in Adulthood: The Young Finns
Study

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Abstract

Objective: To determine the association between cumulative exposure to parent-reported childhood adversities and self-reported adulthood suboptimal sleep. **Methods:** Participants ($n = 1,038$; 57.4% women) were drawn from the prospective population-based Young Finns Study. Childhood adversities were assessed in 1980 among 3- to 18 year olds, while components of suboptimal sleep were measured 27 years later. Cumulative childhood adversities included factors from four domains: stressful life events, adverse parental health behaviors, adverse emotional environment, and low socioeconomic status. Logistic, linear, and ordinal regression analyses were conducted to examine associations between cumulative exposure and self-reported sleep duration, sleep deficiency, and sleep problems, respectively. Multiple imputations were applied to correct for participants lost to follow-up and for missing values (resulting in $n = 3,559$) and the aforementioned analyses were re-run. **Results:** More adverse parental health behaviors (OR = 1.19, CI 95% [1.02–1.38], $p = .03$) and combined childhood adversities (OR = 1.10, CI 95% [1.02–1.19], $p = .02$) were associated with sleeping less than six hours. Neither association withstood adjustment for adulthood health or socioeconomic status or both, nor for attrition bias. No associations were found between adverse childhood environments and sleep deficiency or problems. **Conclusions:** The accumulation of more typical childhood adversities might not persistently affect self-reported sleep duration, sleep deficiency or sleep problems in adulthood. However, this study is among the first to assess the effects of the accumulation of everyday stressors on sleep and therefore, more research is warranted on everyday adversities for more definitive conclusions.

Keywords: sleep problems, sleep duration, sleep deficiency, childhood adversity, stressful life event.

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Suboptimal sleep is a major public health issue since both suboptimal quantity and quality are associated with a range of negative outcomes affecting both individuals and society. These include poor mental (Neckelmann, Mykletun, & Dahl, 2007; Riemann & Voderholzer, 2003; Baglioni et al., 2011) and physical health (Knutson, 2010) accompanied by higher mortality (Hublin, Partinen, Koskenvuo, & Kaprio, 2007) as well as an increased economic burden due to a higher utilization of medical care (Daley et al., 2009; Leger, Guilleminault, Bader, Lévy, & Paillard, 2002) and work-related financial losses (Daley et al., 2009; Metlaine, Leger, & Choudat, 2005; Sivertsen et al., 2006). Suboptimal sleep affects a significant proportion of the general population, since roughly 13.5–14.5% of individuals sleep less than six hours or more than nine hours a night (Kronholm, Harma, Hublin, Aro, & Partonen, 2006), 20% experience sleep deficiency (Hublin, Kaprio, Partinen, & Koskenvuo, 2001), and approximately one-third suffer from one or more sleep problems (Ohayon, 2002). Thus, research on the early origins of suboptimal sleep is needed in order to identify individuals at risk and to focus on early interventions.

Previous research suggests that adversity in childhood may affect suboptimal sleep in adulthood. Most evidence is retrospective and related to the more severe aspects of childhood emotional environment, such as abuse (physical, emotional/verbal, or sexual), neglect, frequent fear of a family member, family conflicts and experiencing high stress load (Bader et al., 2007a; Bader, Schäfer, Schenkel, Nissen, & Schwander, 2007b; Baiden, Fallon, den Dunnen, & Boateng, 2015; Chapman et al., 2011; 2013; Chambers & Belicki, 1998; Greenfield, Lee, & Springer, 2011; Koskenvuo, Hublin, Partinen, Paunio, & Koskenvuo, 2010; Poon & Knight, 2011; Ramsawh, Ancoli-Israel, Sullivan, Hitchcock, & Stein, 2011; Schäfer & Bader, 2013). Furthermore, poorer sleep in adulthood has been retrospectively

associated with other, more common aspects of childhood including parental separation and mental health problems, poorer parental health behaviors like substance abuse (Chapman et al., 2011; 2013; Koskenvuo et al., 2010), and childhood socioeconomic difficulties (Lallukka, Arber, Rahkonen, & Lahelma, 2010; Koskenvuo et al., 2010; Tomfohr, Ancoli-Israel & Dimsdale, 2010). These individual aspects of adverse childhood environment appear important in explaining suboptimal sleep in adulthood, at least when childhood factors are assessed retrospectively. While retrospective reports can better measure more extreme adversities, they are subject to several sources of bias, and in particular, more subtle psychological factors demonstrate low levels of validity in retrospective reports (Hardt & Rutter 2004; Henry, Moffitt, Caspi, Langley, & Silva, 1994). Thus, retrospective reports should be interpreted with great caution (Henry et al., 1994).

It has been argued that cumulative exposure predisposes an individual to multiple negative health outcomes and is more harmful than a singular exposure (Repetti, Taylor, & Seeman, 2002; Evans, Li & Whipple, 2013). Adversities tend to accrue for some individuals as, for example, according to the risky family model, risky family characteristics predispose individuals to experience more adversities (Repetti et al., 2002). Cumulative stress does not allow sufficient recovery time for homeostatic processes (Repetti et al., 2002), thus leading to chronic stress, which, in turn, carries harmful consequences according to the allostatic load model (McEwen, 1998). In addition to other negative health outcomes, retrospective cumulative exposure has been associated with suboptimal sleep. With each additional adversity experienced, the odds for troubled sleep increase by 10% (Baiden et al., 2015), and exposure to three to six adversities (Koskenvuo et al., 2010) and more than five childhood adversities has been associated with a twofold risk of poorer self-reported sleep in adulthood (Chapman et al., 2011; 2013). These findings highlight the importance of examining the effect of cumulative exposure to adversities on adulthood sleep.

Furthermore, prospective measurements have rarely been used in previous studies. Even less is known about prospectively measured accumulation of more common adversities' relation to sleep in adulthood, although it has been shown that everyday adversities predict obesity, depression, coronary artery calcification, diabetes and cardiovascular health (Elovainio et al., 2015; 2017; Juonala et al., 2016; Pulkki-Råback et al., 2015; 2017). To our knowledge, only three prospective studies have examined the association between adverse childhood and sleep patterns in adulthood, although these studies did not examine cumulative exposure. A study by Gregory et al. (2006) showed that childhood family conflicts were associated with insomnia in early adulthood, whereas Noll and colleagues (2006) found an association between sexual abuse and poor sleep in adulthood. These studies featured relatively short follow-up periods with adulthood referring to approximately 18 years of age (Gregory et al., 2006; Noll et al., 2006). Contradictorily, a study by Abajobir et al. (2017) showed that childhood maltreatment, apart from physical abuse in males, did not predict poor overall quality of sleep in young adults.

In this prospective study, the same individuals were followed for 27 years from childhood and adolescence through middle adulthood. The study focused on cumulative exposure to a variety of childhood adversities and used different respondents at baseline and follow-up, thus eliminating the common rater bias. More specifically, it was sought to determine if parent-reported cumulative exposure to childhood adversities predicts self-reported sleep duration, sleep deficiency, and sleep problems in adulthood. We adjusted our analyses for a variety of potential confounding factors contributing to sleep problems in adulthood, including age (Krueger & Friedman, 2009) gender (Ohayon, 2002), smoking (Krueger & Friedman, 2009; Phillips & Danner, 1995), drinking (Krueger & Friedman, 2009), physical activity (Ohayon & Vecchierini, 2005), body mass index ([BMI]) (Gangwisch, Malaspina, Boden-Albala & Heymsfield, 2005), and depression (e.g. Tsuno,

Besset, & Ritchie, 2005), as well as education (Ohayon & Vecchierini, 2005), unemployment (Krueger & Friedman, 2009), and shift work (Ohayon, 2002). Based on previous research, we hypothesized that parent-reported cumulative exposure to childhood adversities predicts a greater number of self-reported sleep problems, decreased sleep duration, and higher levels of sleep deficiency.

Methods

Study sample

Participants were selected from the on-going, prospective, population-based Young Finns study described in more detail in previous publications (Raitakari et al., 2008; Åkerblom et al., 1991). The current study includes data from baseline ($n = 3,596$) and follow-up in 2007 ($n = 2,058$) concerning adverse childhood environment and sleep assessment, respectively. At baseline, subjects were 3, 6, 9, 12, 15, and 18 years, while in 2007 they were 30, 33, 36, 39, 42 and 45 years. The children were randomly selected from the national social security register, which includes all living children in Finland, thus representing the demographic structure of the Finnish population. For sleep assessment, 1,762 participants and for adverse childhood environment, 1,221 participants had complete data. Including covariates, 1,054 participants had complete data on all the study variables. Those who reported being pregnant or had missing data on a pregnancy ($n = 37$) in 2007 were excluded because the subjective quality of sleep can be disturbed and sleep duration may vary according to trimester during pregnancy (Hedman, Pohjasvaara, Tolonen, Suhonen-Malm, & Myllylä, 2002). Thus, the final sample included 1,038 participants (57.5% women) who had full data on all study variables including covariates. Informed consent was received from all participants. The baseline data collection was approved by the research ethics committee of all participating universities (i.e. University of Turku, University of Tampere, University of

Helsinki, University of Kuopio and University of Oulu) and the follow-up data collections were approved by the ethics committee of the University of Turku (the coordinator of this study) (Åkerblom et al., 1985).

Procedure

The participants' clinical examinations (e.g. weight and height) took place at the University Hospital's premises, where the participants had been invited by a written letter. Children aged 12 and under were invited with their parent/s. Written informed consent was obtained on site before any measurements took place. A trained nurse drew the blood samples and measured height and weight. In the 1980 study phase, the clinical examinations took approximately 0.5–1.0 hours per participant, including waiting times. At later study phases the clinical examinations took longer because more examinations were conducted (e.g., ultrasounds of the arteries).

Self-report data were collected via questionnaires mailed to families' homes. The questionnaires comprised questions on socioeconomic status, demographic variables, psychological variables, health behaviors, and diseases. In 1980, parent/s responded to the questionnaires concerning childhood adversities while in 2007 participants responded themselves. The parent/s or the participants filled in the questionnaires and returned them by post or alternatively brought them to the clinical examination. From 2007 onwards, the questionnaires have been sent online, but the participants have also had the option to fill in paper-and-pencil questionnaires (for instance, if they could not access the website).

Measurements

Sleep measurements. Self-reported sleep measurements were collected in 2007. Participants answered questions on their typical *sleep duration* and self-perceived *need for sleep* on a 10-point scale (5 hours or less, 6 hours, 6.5 hours, 7 hours, 7.5 hours, 8 hours, 8.5 hours, 9 hours, 9.5 hours, or 10 hours or more). *Sleep duration* was then categorized into three groups: (1) sleeping 6 hours or less, (2) sleeping 6.5 to 8.5 hours (reference category), and (3) sleeping 9 hours since the extreme ends are considered suboptimal (Kronholm et al., 2006). We assessed sleep duration as it has been repeatedly associated with various health problems (Cappuccio et al., 2008; Gangwisch et al., 2006; Kronholm et al., 2006) and previous studies indicate that adversities may affect sleep duration (Schafer & Bader, 2013). *Sleep deficiency* was defined by subtracting sleep duration from the self-perceived need for sleep. Sleep deficiency was included as an additional measure with the aim of assessing sleep as widely as possible. *Sleep problems* were assessed using Jenkins's scale (Jenkins, Stanton, Niemcryk, & Rose, 1988). Jenkins's scale has been shown to be a valid and reliable measure (Crawford, Pault, Lai, & Sarzi-Puttini, 2010; Halonen et al., 2012; Jenkins et al., 1988; Lallukka et al., 2012) and it captures a broad array of problems associated with sleep including low quality of sleep. The scale consists of four items that measure problems falling asleep, awakening during sleep, difficulty remaining asleep (including waking too early), and feeling tired after a night's sleep. These correspond to the symptoms of insomnia listed in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association 4th edition, 1994). Responses included the following: (1) none at all, (2) 1–3 nights in a month, (3) about 1 night a week, (4) 2–4 nights a week, (5) 5–6 nights a week, and (6) every night. The severity of sleep problems was defined by assigning the value of the most frequent symptom (ranging from 1 to 6 as described above), where a higher value indicated more frequent sleep problems similar to a previous study (Salo et al., 2010).

Childhood Adverse Environment. The childhood environment was categorized using four composite scores representing *stressful life events*, *adverse emotional environment*, *adverse parental health behaviors*, and *low socioeconomic status domains*, which together form the *combined childhood adversity score* (ranging from 0 to 29). Table 1 presents the definitions of these domains. The components of an adverse childhood environment were assessed in 1980 using a questionnaire completed by a parent. The parents were defined as those who took care of the child in the same household and whether the parent was biological was not asked. Therefore, biological and non-biological parents were not separated. It has been previously reported that 97% of the responding parents were mothers (Savelieva et al., 2017). Each composite score is established by assigning a value of 1 for each existing risk and 0 for each non-existent risk; then, the sum of all scores determines the cumulative score. This approach, using binary risk factors known as cumulative risk (CR), carries several advantages: it is parsimonious, has statistical sensitivity and reduced measurement error, does not consist of multiple collinear predictors, and fits well with theoretical models (e.g., allostatic load model) (Evans et al., 2013). Furthermore, this approach has been used in previous studies (Elovainio et al., 2015; 2017; Hakulinen et al., 2016; Pulkki-Råback et al. 2015).

Stressful life events. Parent-reported stressful life events represent instabilities within the family environment consisting of nine variables; each representing one point: *moving residence* three or more times, *changing schools* one or more times, and *parental divorce or separation*, and the following scored separately for each parent; *parental hospitalization* for more than 10 days, *parental death*, and *parental mental illness*. The value of the composite score ranged from 0 to 9.

Adverse emotional environment. Parent-reported adverse emotional environment score consists of four variables. Intolerance and insignificance were assessed using a scale

based on the operation family study (Makkonen et al. 1981) and that has been previously used (Dobewall, et al., 2018a; Hintsanen et al., (in press); Savelieva, et al., 2017a; 2017b). *Intolerance* of the parent towards the child was assessed using three items measured on a five-point scale (i.e., ‘In a difficult situation the child is a burden’, where 1 = not at all, 5 = a great deal, $\alpha = .66$), worth one point when responses 4 or 5 were recorded for at least one of the questions. *Insignificance* of the child was assessed using four items measured on a five-point scale (i.e., ‘The child is significant to me’, 1 = not at all, 5 = a great deal, $\alpha = .60$; reversed scale), worth one point when responses 4 or 5 were recorded for at least one of the questions. Responses to at least 50% of the items on each scale were required. Furthermore, *dissatisfaction with life* was assessed using a five-point scale (1 = satisfied, 5 = dissatisfied, $\alpha = .68$) across three questions concerning satisfaction with parenthood, intimate relationships, and work, worth one point when responses 4 or 5 were recorded for at least one of the questions as described previously (Dobewall et al., 2018b). Finally, *whether or not the parents had time for each other* was assessed using a five-point scale (1 = enough time for each other, 5 = no time for each other), worth one point for a response of 4 or 5. The value of the composite score ranged from 0 to 4.

Adverse parental health behaviors. Parent-reported adverse parental health *behaviors* consisted of four variables, each coded separately for each parent and representing a score of one point: *obesity* among a parent defined as body mass index (BMI) over 30, self-reported *daily smoking*, self-rated *excessive alcohol use* when a parent reported feeling intoxicated due to alcohol use at least once a week, and self-rated *physical inactivity* of a parent assessed on a three-point scale (1 = minimal physical activity during leisure time, 3 = regular physical activity) and defined by responses of minimal physical activity. The value of the composite score ranged from 0 to 8.

Low socioeconomic status. Parent-reported low socioeconomic status consisted of five components coded separately for each parent and worth one point: *unemployed/retired/long-term sick leave*, and a *low parental occupational status* defined as having a manual-labor occupation. Among entrepreneurs, the parent was classified as having a manual-labor occupation if the parent completed less than nine years of education. *Low parental education* was defined as completing nine or less years of education, because that is the time required to complete compulsory school in Finland, which means that people having a maximum of nine years of education have no secondary-degree education. Furthermore, the following were worth one point: a *low combined family income* defined as having 50% or less of the median income of a two-parent household (99.8% of the participants lived in two-parent households) according to the recommendations of the European Union and *household overcrowding* defined by dividing the number of rooms by the number of household members, where the result equals or falls below 0.5. The value of the composite score ranged from 0 to 8.

(Insert Table 1 here)

Potential confounders. Self-reported *educational level* in 2007 was classified as (1) comprehensive school, (2) secondary education (high school, vocational school), (3) bachelor's level (including those completing some university studies but earning no degree) (4) master's degree, and (5) licentiate's or doctoral degree. *Employment status* was coded as follows: (1) those active in working life and (0) those inactive or unemployed. *Work schedule* was coded as follows: (0) regular daytime work or not working outside the home and (1) working other than regular daytime hours. Health-related behaviors included *smoking status* (daily smokers vs. others), *alcohol consumption* (how often at least six portions of beer, wine, or spirits were consumed at one time [one portion equals 12 g], ranging from 1 = once a year or never to 6 = at least twice a week), and *physical activity* (an index formed from five items as in Hintsanen et al., 2005) describing the intensity, frequency, hours per week, average

duration, and participation in structured exercises) (Telama, Yang, Laakso, & Viikari, 1997). High scores indicated a high level of physical activity. *BMI* was calculated from weight and height (kg/m^2). Weight was measured using a Seca weight scale and height was measured using a Seca anthropometer. The severity of *depressive symptoms* was assessed using Beck's Depression Inventory II (BDI-II) (Beck, Steer, & Brown, 1996) which includes 21 items ($\alpha = 0.92$), each consisting of four response alternatives coded from 0 to 3. A dichotomous score based on standardized cut-off scores was used, where 1 = those with depressive symptoms (BDI-II score ≥ 14) and 0 = those with minimal or no symptoms (BDI-II score ≤ 13). *Regular use of prescription drugs* was coded as follows: (1) regularly using prescription drugs, (0) no regular use of prescription drugs.

Statistical analyses

Confirmatory factor analysis for the risk domains. A confirmatory factor analysis was conducted to examine the structure of the risk domains. The CFA was conducted with *lavaan* package (Rosseel, 2012) in Rstudio (2017) with R version 3.5.1 (R Core Team, 2018). Due to the scaling of the variables, the weighted least squares mean and variance adjusted estimator (WLSMV; see Muthén, 1984; Muthén, du Toit & Spisic, 1997) was used. The reliability of the factors was estimated with the *semTools* package (Jorgensen, Pornprasertmanit, Schoemann, & Rosseel, 2018) with R version 3.5.1 (R Core Team, 2018).

Interaction analyses. Interaction analyses were conducted to see if the younger participants differed from the older participants in regard to childhood adversities and adulthood sleep. As in the baseline, the participants were sampled from six age groups (3-, 6-, 9-, 12-, 15-, and 18 year olds) and the participants were split into three groups according to the developmental stage at baseline: early childhood (aged 3 and 6, $n=362$, 34.9%), middle childhood (aged 9 and 12, $n=364$, 35.1%) and adolescents (aged 15 and 18, $n=312$, 30.0%).

The age interactions showed some associations, but inconsistent and, therefore, inconclusive associations (see Supplement Tables 1–3). In addition to the interaction analyses, the main analyses were rerun with the older cohort (15 and 18 years at baseline study). These results did not meaningfully differ from the results with the sample with all the age groups (see Supplement Tables 4–6). Thus, all analyses were conducted for all the age groups combined.

Main analyses. Multinomial logistic regression analyses were conducted to evaluate the associations between parent-reported adverse childhood environment and self-reported sleep duration less than six and more than nine hours per night. Linear regression analyses were conducted to examine the associations between parent-reported adverse childhood environments and self-reported sleep deficiency and ordinal regression analyses to evaluate the associations with self-reported sleep problems based on previous research (Hintsanen et al., 2014). In total, five models were created. In addition to childhood risks, the participants' own health-related behaviors and current SES-related variables were included in our analyses as covariates: model 1 included age and gender; model 2 included age, gender, education, working full-time, and irregular working times or shift work; model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; model 4 adjusted for all covariates; and model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). As the alcohol consumption measure used here might assess binge drinking, and drinking smaller amounts of alcohol might also affect sleep, we ran additional analyses (models 3 to 5) with average daily consumption of alcohol proportions (12gs of alcohol). This did not change the results. The analyses were performed using IBM SPSS software version 25.

Analyses with multiple imputations. Imputation procedures were conducted to correct for any possible bias resulting from missing values at baseline and due to participants lost to follow-up (White, Royston, & Wood, 2011). All available data from the study variables in 1980 and 2007 were used. The amount of missing values in each variable is presented in Supplement Table 7 (ranging from 15 to 43%). As the number of missing observations was high, we followed the suggestion by White et al. (2011) reaching a greater number of imputations than of missing observations in addition to the guidance received from the statistical expert in our department. All missing values for any of the variables were imputed applying the multiple imputation method using chained equations from STATA 14. The primary statistical analyses mentioned above were rerun using the imputed data ($n = 3,559$). The pooled estimates for 50 imputed datasets are reported.

Results

Table 2 presents the characteristics of the study sample, while Supplement Table 8 provides the characteristics of the imputed sample. The attrition analyses are presented in Supplement Table 9. They showed some significant differences between excluded and included participants. Using a t-test, we found that included participants ($n = 1,038$) compared with those excluded ($n = 2,558$) from the study had on average fewer sleep problems ($M = 3.19$ vs. $M = 3.33$, $p = .03$), fewer adverse parental health behaviors ($M = 1.25$ vs. $M = 1.39$, $p = .01$), a higher socioeconomic status ($M = 2.21$ vs. $M = 2.50$, $p < .001$) and a less adverse emotional environment ($M = 0.41$ vs. $M = 0.49$, $p = .003$). We also found that those included in our sample, on average, completed a higher level of education ($M = 2.89$ vs. $M = 2.62$, $p < .001$) and were more physically active ($M = 9.72$ vs. $M = 9.35$, $p < .001$), but smoked less on a daily basis (14.7% vs. 21.8%, $p = .001$), abused substances less ($M = 2.42$ vs. $M = 2.56$, $p = .021$), engaged in less shift work ($M = 29.5\%$ vs. $M = 33.9\%$, $p = .03$), and exhibited a lower BMI ($M = 25.73$ vs. $M = 26.26$, $p = .01$). Our participants were also a little younger ($M =$

37.18 vs. $M = 37.55$, $p = .04$) and were more likely to be women (57.5% vs. 42.3%, $p < .001$). Those included and excluded did not differ in terms of the number of stressful life events reported, rates of depression, or whether they worked full-time or not. After adjusting the significance for the number of analyses ($p = .05/15 =$ significant p -value $.003$) differences in gender, adverse socioeconomic status, education, daily smoking and physical activity remained significant.

The results from the confirmatory factor analyses are presented in the Supplement Table 10. The factor analysis suggested acceptable fit for a model with four risk domains ($\chi^2 [318] = 758.282$, $p < .001$, CFI= 0.883, TLI=0.871, RMSEA= 0.037, 95% CI [0.033-0.040]). The reliability estimates were adverse events ($\alpha = .74$), emotional environment ($\alpha = .66$), adverse parental health behaviors ($\alpha = .72$), and low socioeconomic status ($\alpha = .85$). This result corresponds to a factor structure shown previously (Pulkki-Råback et al., 2015).

Table 3 outlines the results of the multinomial logistic regression analyses for parent-reported adverse childhood environments and self-reported sleep duration. In the gender- and age-adjusted model (model 1), more adverse parental health behaviors (OR = 1.19, CI 95% [1.02–1.38], $p = .03$) and the combined childhood adversity score (OR = 1.10, 95% CI [1.02–1.19], $p = .02$) were associated with sleeping less than six hours. When adjusting the significance level to the number of analysis ($p = .05/15 =$ significant p -value $.003$), these associations did not remain significant. Adding other control variables attenuated these associations to non-significant. Tables 4 and 5 present the associations for parent-reported components of adverse childhood environment on self-reported sleep deficiency and sleep problems. No significant associations were found for these sleep-related issues.

We repeated the analyses using the multiple imputed data. The results are presented in Supplement Tables 11–13. The combined childhood adversity score was associated with

sleeping less than six hours (OR = 1.05, 95% CI [1.00–1.11], $p = .05$) and the association between more adverse parental health behaviors with self-reported sleeping less than six hours approached significance ($p=.06$) in model 1 in the imputed data.

(Insert Tables 2 to 5 here)

Discussion

The results from a prospective 27-year follow-up study suggest that parent-reported cumulative exposure to adverse childhood environment was not associated with self-reported sleep deficiency or with sleep problems; exposure, however, to adverse parental health behaviors increased the risk of self-reported sleeping less than six hours each night. As the score for adverse parental health behaviors increased by one point, odds for their offspring sleeping less than six hours per night in adulthood increased approximately by 19%. However, adjusting the p-value and controlling for the adult environment attenuated this association to a non-significant level, as did controlling for any attrition-related bias using multiple imputations. Findings from the current study suggest that no strong or persistent associations exist between parent-reported more typical childhood adversities and self-reported suboptimal sleep in adulthood. These associations may, however, differ with regard to more severe adversities including various types of abuse.

While the accumulation of childhood adversities contributes to health issues later in life (McEwen, 1998; Repetti et al., 2002), this did not readily manifest in terms of self-reported suboptimal sleep in our sample. Parent-reported childhood adversities, primarily poor parental health behaviors, were associated with self-reported shorter sleep duration, although this association did not withstand adjustment for the adulthood factors. In the risky family model (Repetti et al., 2002), children's vulnerability to poor health behaviors increases in the

face of adversity, which further places children at risk for long-term adverse mental and physical health outcomes. The exposure to parents' unhealthy habits makes such behaviors more familiar and acceptable and thus, promotes the development of poor health behaviors, which in turn impair sleep in adulthood. Several studies on other health behaviors are roughly in line with this model (Burke, Beilin, & Dunbar, 2001; den Exter Blokland, Engels, Hale, Meeus, & Willemsen, 2004; Gilman et al., 2009; Li, Law, Conte, & Power, 2009; Lieb et al., 2002; Mays et al., 2014; White, Johnson, & Buyske, 2000 Yu, 2003).

However, no other associations were found between parent-reported childhood adversities and self-reported suboptimal sleep, although this association has been shown several times in previous research (Bader et al., 2007a; 2007b; Baiden et al., 2015; Chapman et al., 2011; 2013; Chambers & Belicki, 1998; Greenfield et al., 2011; Kajeepeta, Gelaye, Jackson, & Williams, 2015; Koskenvuo et al., 2010; Poon & Knight, 2011; Ramsawh et al., 2011; Lallukka et al., 2010; Tomfohr et al., 2010; Schäfer & Bader, 2013) with the exception of one prospective study (Abajobir et al., 2017). This prospective study showed that childhood maltreatment, apart from physical abuse in males, was not associated with a subjective overall score of sleep quality. Although they assessed more severe forms of adversity, their sleep quality measure partly corresponds to our measures of sleep duration and problems, and thus, support the current findings of the association between childhood adverse experiences and suboptimal sleep in adulthood.

One explanation for these contradictory findings may lie in the retrospective nature of most previous studies. Instead of assessing true adversity, retrospective reports may suffer from a reporting bias. For instance, reporting the experiences of childhood adversities may reflect psychological maladaptation, in turn interfering both with sleep and reporting tendencies. Another explanation for the differing results may result from inclusion of everyday adversities, whereas previous studies primarily included rather severe aspects of the

childhood environment prone to impact sleep patterns to a larger degree. A recent review supports this assessment stating that the strength of any association between childhood adversities increased with the number and severity of adversities experienced (Kajeepeeta et al., 2015).

If our finding of the association between childhood adverse experiences and suboptimal sleep in adulthood is confirmed in future studies, it has clinical relevance for prevention of suboptimal sleep. If childhood everyday stressors or even their accumulation do not affect sleep in adulthood, interventions should be directed to more severe adversities. However, as this is among the first studies assessing the effects of the accumulation of everyday stressors on sleep, more research is needed on the origins and factors maintaining suboptimal sleep to draw conclusive implications.

Study limitations include significant attrition, which can be expected when participants are followed for nearly three decades. Those suffering from suboptimal sleep might have a higher rate of drop-out, and therefore, the overall results could underestimate the amount of suboptimal sleep. The included participants reported fewer sleep problems and less parental adverse emotional, health, and socioeconomic factors. However, the number of participants having one or more sleep problem is comparable with previous estimates. Previously, approximately one-third of the population has been estimated to suffer from one or more sleep problems (Ohayon, 2002). In our study, 42.6% of the participants suffered from one or more sleep problem at least two to four nights a week (and 18.4% suffered at least five nights a week). Furthermore, rates of suboptimal sleep duration are comparable to previous estimates. Kronholm et al. (2006) estimated 13.5–14.5% suffer from suboptimal sleep duration. In our study, the rates were 8.4% for 6 hours or less and 4.0% for 9 hours or more, which together is 12.4% and close to the estimates reported by Kronholm et al. (2006). The rate of those sleeping at least an hour less than needed was lower, 5.2%, compared to the

estimate of 20% suffering from sleep deficiency (Hublin et al., 2001). Additionally, a multiple imputation was conducted to examine and correct for the effects of participant dropout. Analyses with imputed data revealed no significant associations. This indicates that the non-significant findings were not a result of attrition, whereas significant findings in the non-imputed data may have been caused by attrition.

Study limitations also include factors limiting generalizability. The mean level of adversity endorsed in the current study was not high. Parental reporting of the adversities might have skewed the answers, and homogeneity of the sample with almost all children from two-parent households lower the rates of adversity. Therefore, the results might not be generalizable to populations that include a larger proportion of underprivileged families. Furthermore, some of the selected variables, including sleep assessments, might not be ideal measurement approaches. Sleep was assessed using self-reports and additional or more objective information could be collected using electroencephalogram or actigraphy. In addition, chronic diseases affecting sleep, apart from depression, were not directly controlled in the analyses. In order to address this, we included other factors likely tapping markers and risks of chronic diseases, i.e. obesity, physical inactivity, drinking, smoking and regular use of prescription drugs.

Another clear limitation is that because of the large age range of our participants (3–18 years), the oldest cohorts had events measured throughout childhood and adolescence while for the younger children we had a much shorter time for measuring life events, and thus not all adversities are necessarily captured in the younger participants. Because of the adversities occurring after the initial measurement point was not recorded, the number of events depends on the age of the child. However, the age interaction analysis showed inconclusive associations and the analysis rerun with the two oldest age groups did not show meaningfully different results from those run with the whole sample.

Despite these limitations, the current study also has a number of strengths. First, prospective study design was used with different respondents reporting childhood adversities and adulthood sleep, as the initial data concerning participants was reported by their parents while in 2007 participants reported themselves. This carries many advantages, including, for example, diminishing memory bias and reducing the effect of common rater bias. Second, the study relied on a representative sample with a long follow-up time of 27 years, enabling determination of whether childhood factors have a persistent effect on self-reported adulthood sleep. Third, the analysis encompassed a wide variety of childhood adversities. Finally, a non-clinical population was used, yielding an accurate understanding of how the accumulation of everyday adversities in childhood affects sleep in adulthood in the general population. This allowed avoiding selection-related effects better than clinical studies.

Conclusions

While more severe adversities may have a lasting effect on adulthood sleep, these findings suggest that experiencing cumulative exposure to everyday adversities in childhood minimally affects self-reported sleep in adults. This is an encouraging finding since it illustrates that more typical childhood adversities might not have a lasting independent effect resulting in suboptimal sleep. To our knowledge, this study represents the first prospective, population-based study on cumulative exposure to childhood adversities predicting adulthood sleep. The findings warrant more research, especially with different types of childhood adversity and sleep in adulthood in prospective designs.

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ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Table 1
Definitions of Components of an Adverse Childhood Environment (Coded as Present vs. Absent)

Component	Definition of an Adverse Level
Stressful life events	
Moving residence	Change of residence three or more times during youth
Changing schools	Change of school two or more times
Parental relationship	Parental divorce or separation
Maternal long-term sickness	Hospitalisation for more than 10 days
Paternal long-term sickness	Hospitalisation for more than 10 days
Death of a family member	Maternal death
	Paternal death
Maternal mental health	Diagnosed mental illness
Paternal mental health	Diagnosed mental illness
Adverse emotional environment	
Tolerance towards the child	Intolerance towards the child
Significance of the child	Insignificance of the child
Time parents have together	Little or no time for each other
Satisfaction with life	Dissatisfaction with at least one area of life
Adverse parental health behaviors	
Maternal body mass index	BMI ≥ 30
Paternal body mass index	BMI ≥ 30
Maternal smoking	Daily smoking
Paternal smoking	Daily smoking
Maternal alcohol use	Intoxication \geq one time a week
Paternal alcohol use	Intoxication \geq one time a week
Maternal physical activity	Minimal physical activity
Paternal physical activity	Minimal physical activity
Low socioeconomic status	
Maternal education	≤ 9 years of education
Paternal education	≤ 9 years of education
Maternal employment	Unemployed, retired, or sick leave
Paternal employment	Unemployed, retired, or sick leave
Maternal occupational status	Manual-labor occupation
Paternal occupational status	Manual-labor occupation
Family income	\leq lowest 25%
Household overcrowding	Number of rooms per number of household members ≤ 0.5

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Table 2
Descriptive Statistics of the Study Sample (n = 1,038)

Variable	Mean	SD	Range	Number	%
Age	37.18	4.97			
Gender				596	57.4
				442	42.6
Stressful life events (0–9) ^a	0.25	0.54	0–4		
Adverse emotional environment (0–4) ^a	0.41	0.72	0–4		
Adverse parental health behaviors (0–8) ^a	1.25	1.34	0–7		
Low socioeconomic status (0–8) ^a	2.21	1.92	0–7		
Combined childhood adversity (0–29) ^{a,b}	4.12	2.74	0–13		
Sleep duration					
				87	8.4
				909	87.6
				42	4.0
Sleep deficiency (-3–5) ^c	0.48	0.84			
Sleep problems (1–6)	3.20	1.49			
No sleep problems				125	12.0
1–3 nights in a month				289	27.8
1 night a week				182	17.5
2–4 nights a week				251	24.2
5–6 nights a week				82	7.9
Every night				109	10.5
Family size at baseline	4.50	1.23			
Number of children in the family	2.62	1.39			
Number of children living home	2.37	1.15			
Two parent households				1036	99.8
Single parent households (100% mothers)				2	0.2

^a Theoretical range, ^b the number of adversities depended on age ($r=.19$, $p<.001$), ^c The rate of those sleeping at least an hour less than needed was 5.2%.

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Table 3

Multinomial Logistic Regressions Analyses of the Association Between Adverse Childhood Environment and Sleep Duration (n = 1,038; reference category 6.5 to 8.5 hours of sleep)

	Model 1			Model 2			Model 3			Model 4			Model 5		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Stressful life events															
≤6 hours	1.24	(0.84–1.83)	.27	1.31	(0.89–1.93)	.18	1.20	(0.81–1.78)	.37	1.27	(0.86–1.89)	.23	1.25	(0.84–1.86)	.28
≥9 hours	0.79	(0.39–1.57)	.50	0.80	(0.40–1.59)	.52	0.77	(0.38–1.57)	.47	0.80	(0.40–1.62)	.54	0.80	(0.40–1.62)	.54
Adverse emotional environment															
≤6 hours	1.26	(0.95–1.66)	.11	1.24	(0.93–1.65)	.14	1.25	(0.94–1.66)	.13	1.24	(0.93–1.65)	.15	1.21	(0.90–1.62)	.22
≥9 hours	0.90	(0.56–1.44)	.66	0.91	(0.56–1.45)	.68	0.92	(0.57–1.48)	.72	0.91	(0.56–1.49)	.71	0.92	(0.56–1.51)	.73
Adverse parental health behaviors															
≤6 hours	1.19	(1.02–1.38)	.03	1.13	(0.97–1.32)	.13	1.12	(0.96–1.31)	.16	1.08	(0.93–1.27)	.32	1.06	(0.90–1.25)	.47
≥9 hours	1.02	(0.81–1.28)	.89	0.99	(0.78–1.26)	.92	1.00	(0.79–1.27)	.99	0.98	(0.77–1.25)	.87	0.99	(0.77–1.27)	.91
Low socioeconomic status															
≤6 hours	1.06	(0.95–1.19)	.31	1.00	(0.88–1.13)	.97	1.04	(0.92–1.17)	.57	0.99	(0.87–1.12)	.89	0.99	(0.87–1.12)	.82
≥9 hours	1.07	(0.91–1.26)	.43	1.03	(0.86–1.22)	.78	1.05	(0.89–1.24)	.59	1.01	(0.85–1.21)	.88	1.01	(0.85–1.21)	.88
Combined childhood adversity															
≤6 hours	1.10	(1.02–1.19)	.02	1.06	(0.98–1.16)	.15	1.07	(0.99–1.16)	.09	1.05	(0.96–1.14)	.31			
≥9 hours	1.02	(0.91–1.15)	.71	0.99	(0.88–1.12)	.92	1.01	(0.90–1.14)	.88	0.99	(0.87–1.12)	.84			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations were reduced to non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Table 4
Linear Regression Analyses of the Association Between Adverse Childhood Environment and Sleep Deficiency (n = 1,038)

	β	95% CI	R^2	p
Stressful life events				
Model 1	0.07	(-0.03-0.17)	.01	.19
Model 2	0.07	(-0.03-0.17)	.01	.17
Model 3	0.05	(-0.05-0.14)	.06	.35
Model 4	0.05	(-0.05-0.15)	.06	.33
Model 5	0.05	(-0.05-0.14)	.06	.36
Adverse emotional environment				
Model 1	0.03	(-0.04-0.11)	.01	.37
Model 2	0.03	(-0.04-0.11)	.01	.38
Model 3	0.03	(-0.04-0.10)	.06	.41
Model 4	0.03	(-0.04-0.10)	.06	.42
Model 5	0.02	(-0.05-0.09)	.06	.55
Adverse parental health behaviors				
Model 1	0.03	(-0.01-0.06)	.01	.21
Model 2	0.03	(-0.01-0.06)	.01	.21
Model 3	0.02	(-0.02-0.05)	.06	.44
Model 4	0.02	(-0.02-0.06)	.06	.39
Model 5	0.02	(-0.02-0.06)	.06	.40
Low socioeconomic status				
Model 1	-0.01	(-0.03-0.02)	.01	.60
Model 2	-0.01	(-0.04-0.02)	.01	.48
Model 3	-0.01	(-0.04-0.02)	.06	.42
Model 4	-0.01	(-0.04-0.02)	.06	.41
Model 5	-0.01	(-0.04-0.02)	.06	.36
Combined childhood adversity				
Model 1	0.01	(-0.01-0.03)	.01	.45
Model 2	0.01	(-0.01-0.03)	.01	.50
Model 3	0.002	(-0.02-0.02)	.06	.83
Model 4	0.003	(-0.02-0.02)	.06	.78
Model 5				

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations remained non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Table 5
Ordinal Regressions on the Associations Between Adverse Childhood Environment and Sleep Problems (n = 1,038)

	OR	95% CI	p
Stressful life events			
Model 1	1.20	(0.97–1.48)	.10
Model 2	1.17	(0.95–1.44)	.15
Model 3	1.12	(0.91–1.38)	.29
Model 4	1.09	(0.88–1.35)	.43
Model 5	1.09	(0.89–1.34)	.44
Adverse emotional environment			
Model 1	1.06	(0.91–1.23)	.49
Model 2	1.06	(0.91–1.24)	.47
Model 3	1.02	(0.87–1.19)	.82
Model 4	1.02	(0.88–1.19)	.77
Model 5	1.02	(0.87–1.19)	.79
Adverse parental health behaviors			
Model 1	1.01	(0.93–1.09)	.89
Model 2	1.01	(0.93–1.10)	.81
Model 3	0.98	(0.90–1.06)	.58
Model 4	0.99	(0.91–1.08)	.75
Model 5	0.99	(0.91–1.08)	.77
Low socioeconomic status			
Model 1	0.98	(0.92–1.03)	.41
Model 2	0.98	(0.92–1.04)	.44
Model 3	0.97	(0.92–1.03)	.32
Model 4	0.98	(0.92–1.04)	.50
Model 5	0.98	(0.92–1.04)	.56
Combined childhood adversity			
Model 1	1.00	(0.96–1.04)	.99
Model 2	1.00	(0.96–1.05)	.93
Model 3	0.99	(0.95–1.03)	.48
Model 4	0.99	(0.95–1.04)	.70
Model 5			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations remained non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 1

Multinomial Logistic Regression Analyses of the Interaction Association Between Adverse Childhood Environment and Sleep Duration (n = 1,038)

	≤6 hours			≥9 hours		
	OR	95% CI	p	OR	95% CI	p
Adverse emotional environment						
Youngest* Emot. Environment	1.30	(0.64–2.64)	.48	0.86	(0.29–2.53)	.78
Middle* Emot. Environment	1.01	(0.46–2.22)	.99	0.56	(0.15–2.16)	.41
Adverse parental health behaviors						
Youngest*Health behaviors	1.15	(0.81–1.65)	.43	1.28	(0.72–2.25)	.40
Middle* Health behaviors	1.00	(0.69–1.46)	.99	1.04	(0.57–1.90)	.90
Low socioeconomic status						
Youngest*SES	1.06	(0.79–1.41)	.71	1.08	(0.73–1.61)	.71
Middle*SES	1.08	(0.82–1.42)	.56	0.66	(0.44–1.01)	.06
Combined childhood adversity						
Youngest*Combined Adversity	1.07	(0.89–1.30)	.47	1.08	(0.88–1.30)	.62
Middle*Combined Adversity	1.03	(0.85–1.24)	.79	0.78	(0.58–1.05)	.10

Note. Reference the oldest group. Youngest: 3 and 6 –years at baseline, n=364 (35%); Middle: 9 and 12 years at baseline, n= 365 (35%), Oldest = 15 and 18-years at baseline, n=312 (30%). All models were adjusted for the main effects. After adjusting the significance level for the number of analyses ($p=.05/15= .003$) all associations remained non-significant.

Supplement Table 2

Linear Regression Analyses of the Interaction Association Between Adverse Childhood Environment and Sleep Deficiency (n = 1,381)

	β	95% CI	p
Stressful life events			
Youngest* Stressful Events	0.15	(-0.27-0.57)	.49
Middle*Stressful Events	0.14	(-0.06-0.35)	.17
Adverse emotional environment			
Youngest* Emot. Environment	0.20	(0.01-0.38)	.04
Middle* Emot. Environment	0.13	(-0.07-0.32)	.21
Adverse parental health behaviors			
Youngest*Health behaviors	0.07	(-0.02-0.17)	.12
Middle* Health behaviors	0.09	(-0.01-0.18)	.07
Low socioeconomic status			
Youngest*SES	-0.01	(-0.08-0.06)	.76
Middle*SES	0.04	(-0.03-0.10)	.25
Combined childhood adversity			
Youngest*Combined Adversity	0.03	(-0.02-0.08)	.20
Middle*Combined Adversity	0.05	(0.01-0.10)	.03

Note. Reference the oldest group. Youngest: 3 and 6 –years at baseline, n=364 (35%); Middle: 9 and 12 years at baseline, n= 365 (35%), Oldest = 15 and 18-years at baseline, n=312 (30%). All models were adjusted for the main effects. After adjusting the significance level for the number of analyses ($p=.05/15= .003$) all associations were reduced to non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 3
*Ordinal Regressions on the Interaction Associations Between Adverse
 Childhood Environment and Sleep Problems (n = 1,038)*

	OR	95% CI	p
Stressful life events			
Youngest* Stressful Events	1.34	(0.55–3.24)	.52
Middle*Stressful Events	1.55	(1.00–2.40)	.05
Adverse emotional environment			
Youngest* Emot. Environment	1.15	(0.78–1.70)	.48
Middle* Emot. Environment	1.23	(0.81–1.87)	.33
Adverse parental health behaviors			
Youngest*Health behaviors	1.20	(0.99–1.46)	.07
Middle* Health behaviors	1.22	(1.00–1.49)	.05
Low socioeconomic status			
Youngest*SES	1.00	(0.86–1.15)	.99
Middle*SES	0.92	(0.80–1.05)	.21
Combined childhood adversity			
Youngest*Combined Adversity	1.07	(0.96–1.18)	.21
Middle*Combined Adversity	1.04	(0.94–1.15)	.42

Note. Reference the oldest group. Youngest: 3 and 6 –years at baseline, n=364 (35%); Middle: 9 and 12 years at baseline, n= 365 (35%), Oldest = 15 and 18-years at baseline, n=312 (30%). All models were adjusted for the main effects. After adjusting the significance level for the number of analyses ($p=.05/15= .003$) all associations were reduced to non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 4

Multinomial Logistic Regressions Analyses of the Association Between Adverse Childhood Environment and Sleep Duration with the Oldest Age Groups (15 and 18 years at baseline, n = 312; reference category 6.5 to 8.5 hours of sleep)

	Model 1			Model 2			Model 3			Model 4			Model 5		
	OR	95% CI	p												
Stressful life events															
≤6 hours	1.38	(0.82–2.32)	.22	1.56	(0.91–2.67)	.11	1.35	(0.79–2.30)	.27	1.50	(0.86–2.60)	.16	1.52	(0.87–2.67)	.15
≥9 hours	0.98	(0.39–2.50)	.97	0.98	(0.39–2.47)	.97	0.95	(0.38–2.36)	.90	0.92	(0.36–2.34)	.87	0.88	(0.35–2.26)	.80
Adverse emotional environment															
≤6 hours	1.13	(0.63–2.04)	.68	1.13	(0.62–2.06)	.70	1.02	(0.54–1.94)	.96	1.04	(0.54–2.00)	.90	0.99	(0.51–1.92)	.97
≥9 hours	1.05	(0.45–2.48)	.90	1.11	(0.46–2.64)	.82	1.31	(0.52–3.28)	.56	1.38	(0.54–3.53)	.51	1.65	(0.64–4.28)	.30
Adverse parental health behaviors															
≤6 hours	1.11	(0.86–1.44)	.40	1.04	(0.80–1.35)	.80	1.05	(0.81–1.37)	.71	1.00	(0.76–1.30)	.97	0.99	(0.74–1.31)	.93
≥9 hours	0.95	(0.62–1.45)	.80	0.95	(0.62–1.45)	.81	0.86	(0.54–1.37)	.52	0.84	(0.51–1.37)	.49	0.77	(0.46–1.28)	.31
Low socioeconomic status															
≤6 hours	1.01	(0.84–1.23)	.89	0.97	(0.79–1.20)	.75	1.00	(0.82–1.22)	.99	0.96	(0.78–1.19)	.73	0.96	(0.76–1.20)	.69
≥9 hours	1.21	(0.90–1.62)	.20	1.22	(0.90–1.65)	.20	1.18	(0.87–1.59)	.29	1.20	(0.88–1.63)	.26	1.28	(0.92–1.77)	.15
Combined childhood adversity															
≤6 hours	1.06	(0.93–1.22)	.39	1.03	(0.89–1.19)	.70	1.08	(0.90–1.19)	.63	1.01	(0.88–1.16)	.90			
≥9 hours	1.09	(0.89–1.33)	.42	1.09	(0.89–1.34)	.40	1.06	(0.85–1.32)	.60	1.07	(0.85–1.33)	.57			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations were reduced non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 5

Linear Regression Analyses of the Association Between Adverse Childhood Environment and Sleep Deficiency with the Oldest Age Groups (15 and 18 years at baseline, n = 312)

	β	95% CI	R^2	p
Stressful life events				
Model 1	0.00	(-0.15-0.15)	.02	.99
Model 2	0.02	(-0.13-0.16)	.03	.84
Model 3	-0.01	(-0.14-0.14)	.09	.99
Model 4	0.01	(-0.13-0.16)	.10	.85
Model 5	0.02	(-0.13-0.17)	.11	.78
Adverse emotional environment				
Model 1	-0.09	(-0.24-0.07)	.03	.28
Model 2	-0.09	(-0.24-0.07)	.03	.26
Model 3	-0.05	(-0.21-0.10)	.09	.51
Model 4	-0.06	(-0.21-0.10)	.10	.47
Model 5	-0.07	(-0.23-0.09)	.11	.38
Adverse parental health behaviors				
Model 1	-0.03	(-0.10-0.04)	.03	.43
Model 2	-0.04	(-0.11-0.03)	.03	.27
Model 3	-0.04	(-0.11-0.02)	.10	.21
Model 4	-0.06	(-0.13-0.01)	.11	.12
Model 5	-0.04	(-0.12-0.03)	.11	.22
Low socioeconomic status				
Model 1	-0.02	(-0.07-0.03)	.03	.38
Model 2	-0.03	(-0.08-0.02)	.03	.24
Model 3	-0.03	(-0.08-0.02)	.10	.22
Model 4	-0.04	(-0.09-0.01)	.11	.14
Model 5	-0.03	(-0.08-0.02)	.11	.20
Combined childhood adversity				
Model 1	-0.02	(-0.05-0.01)	.03	.21
Model 2	-0.03	(-0.06-0.01)	.04	.11
Model 3	-0.03	(-0.06-0.01)	.10	.10
Model 4	-0.04	(-0.07-0.00)	.11	.05
Model 5				

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations were remained non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 6
Ordinal Regressions on the Associations Between Adverse Childhood Environment and Sleep Problems with the Oldest Age Groups (15 and 18 years at baseline, n = 312)

	OR	95% CI	<i>p</i>
Stressful life events			
Model 1	0.94	(0.70–1.27)	.68
Model 2	0.92	(0.68–1.25)	.59
Model 3	0.89	(0.66–1.21)	.46
Model 4	0.87	(0.64–1.18)	.37
Model 5	0.86	(0.63–1.17)	.33
Adverse emotional environment			
Model 1	0.93	(0.68–1.28)	.65
Model 2	0.94	(0.68–1.29)	.68
Model 3	0.94	(0.68–1.30)	.71
Model 4	0.95	(0.68–1.32)	.76
Model 5	0.98	(0.70–1.37)	.90
Adverse parental health behaviors			
Model 1	0.90	(0.78–1.04)	.14
Model 2	0.89	(0.77–1.03)	.12
Model 3	0.84	(0.73–0.97)	.02
Model 4	0.84	(0.73–0.98)	.03
Model 5	0.84	(0.72–0.98)	.03
Low socioeconomic status			
Model 1	1.00	(0.91–1.11)	.95
Model 2	0.99	(0.89–1.10)	.86
Model 3	0.99	(0.90–1.10)	.88
Model 4	0.98	(0.89–1.09)	.72
Model 5	1.00	(0.89–1.11)	.93
Combined childhood adversity			
Model 1	0.97	(0.90–1.04)	.37
Model 2	0.96	(0.89–1.03)	.24
Model 3	0.94	(0.88–1.01)	.12
Model 4	0.94	(0.87–1.01)	.08
Model 5			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations were reduced to non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 7

Amount of missing observations in each of the study variables

	N in observed data	Missing (n)	Missing (%)	N in imputed data
Stressful life events	2,841	718	20.2	3,559
Adverse emotional environment	3,013	546	15.3	3,559
Adverse parental health behaviors	2,742	817	23.0	3,559
Low socioeconomic status	2,843	716	20.1	3,559
Sleep Duration	2,228	1,368	38.4	3,559
Sleep Deficiency	2,221	1,375	38.6	3,559
Sleep Problems	2,226	1,370	38.5	3,559
Education	2,191	1,368	38.4	3,559
Working full-time	2,022	1,537	43.2	3,559
Irregular working times or shift work	2,158	1,401	39.4	3,559
Body Mass Index	2,145	1,414	39.7	3,559
Alcohol consumption	2,182	1,377	38.7	3,559
Smoking	2,187	1,372	38.6	3,559
Physical Activity	2,130	1,429	40.2	3,559
Depression	2,024	1,535	43.1	3,559
Regular use of prescription drugs	2,222	1,374	38.6	3,559

Note. Those who were pregnant in 2007 (n=37) were excluded from the imputation model

Supplement Table 8

Descriptive Statistics of the Imputed Study Sample (n = 3,559)

Variable	Mean	SD	Range	Number	%
Age	37.47	5.00			
Gender					
Women				1,795	50.4
Men				1,764	49.6
Stressful life events (0–9) ^a	0.26	0.60	0–4		
Adverse emotional environment (0–4) ^a	0.46	0.83	0–4		
Adverse parental health behaviors (0–8) ^a	1.36	1.57	0–7		
Low socioeconomic status (0–8) ^a	2.44	2.28	0–8		
Combined childhood adversity (0–29) ^a	4.51	3.22	0–18		
Sleep duration					
≤6 hours				364	10.2
6.5–8.5 hours				3,032	85.2
≥9 hours				163	4.6
Sleep deficiency (-3–5)	0.48	1.72			
Sleep problems (1–6)	3.24	1.95			

^aTheoretical range.

Supplement Table 9

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Comparison of the included and excluded participants (Mean (SD)/Percentage)

Characteristic	Included (1,038)	Excluded (2,558)	<i>p</i>
Age	37.18 (0.50)	37.55 (0.50)	.04
Gender	57.5%	42.3%	<.001
Childhood Adversities			
Adverse emotional environment (0-4) ^a	0.41 (0.72)	0.49 (0.97)	.003
Poor parental health behaviors (0-8) ^a	1.25 (1.34)	1.39 (1.35)	.009
Adverse socioeconomic environment (0-8) ^a	2.21 (1.92)	2.50 (1.97)	<.001
Adulthood Sleep			
Sleep problems (1-6)	3.19 (1.49)	3.33 (1.54)	.03
Confounding Variables			
Education	2.89 (0.84)	2.62 (0.85)	<.001
Shift work	29.5%	33.9%	.03
Daily smoking	14.7%	21.8%	.001
Substance use	2.42 (1.37)	2.56 (1.52)	.02
Physical activity	9.72 (2.12)	9.35 (2.14)	<.001
BMI	25.73 (4.47)	26.26 (4.99)	.01

^a Theoretical range.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 10

Summary of Confirmatory Factor Analysis for the Adverse Childhood Environment Components Using Weighted Least Squares Mean and Variance Adjusted Estimator (n=1,038)

	Stressful life events			Adverse emotional environment			Adverse parental health behaviours			Low socioeconomic status		
	β	B	SE	β	B	SE	β	B	SE	β	B	SE
Moving residence	0.30	1.00										
Changing schools	0.16	0.55	0.09									
Parental relationship	0.93	3.13	0.69									
Maternal long-term sickness	0.42	1.43	0.21									
Paternal long-term sickness	0.58	1.96	0.28									
Maternal mental health	0.59	2.01	0.27									
Paternal mental health	0.67	2.25	0.29									
Tolerance towards the child				0.53	1.00							
Significance of the child				0.46	0.83	0.18						
Time parents have together				0.59	1.06	0.17						
Satisfaction with life				0.73	1.32	0.24						
Maternal body mass index							0.60	1.00				
Paternal body mass index							0.28	0.46	0.10			
Maternal smoking							0.34	0.57	0.09			
Paternal smoking							0.41	0.68	0.10			
Maternal alcohol use							0.78	1.30	0.13			
Paternal alcohol use							0.53	0.88	0.09			
Maternal physical activity							0.69	1.15	0.12			
Paternal physical activity							0.78	1.33	0.13			
Maternal occupational status										0.84	1.00	
Paternal occupational status										0.85	1.00	0.03
Maternal education										0.81	0.96	0.04
Paternal education										0.87	1.04	0.03
Maternal employment										0.51	0.61	0.07
Paternal employment										0.60	0.72	0.07
Family income										0.54	0.65	0.05
Household overcrowding										0.41	0.48	0.05

β =standardised factor loading, B= Factor loading, SE=standard error. Death of a family member was omitted due to the low frequency (n=1). Fit of the model: Chi2(318):758.282, CFI=0.883, RMSEA= 0.037.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 11

Imputed Multinomial Logistic Regression Analyses of the Associations Between Adverse Childhood Environment and Sleep Duration (n = 3,559; reference category 6.5–8.5 hours of sleep)

	Model 1			Model 2			Model 3			Model 4			Model 5		
	OR	95% CI	p												
Stressful life events															
≤6 hours	1.18	(0.88–1.57)	.26	1.22	(0.91–1.62)	.18	1.15	(0.86–1.54)	.35	1.18	(0.88–1.58)	.27	1.17	(0.87–1.57)	.29
≥9 hours	1.08	(0.72–1.61)	.72	1.06	(0.71–1.59)	.77	1.05	(0.70–1.57)	.81	1.03	(0.68–1.55)	.89	1.04	(0.69–1.56)	.86
Adverse emotional environment															
≤6 hours	1.02	(0.85–1.24)	.82	1.00	(0.83–1.21)	.99	0.99	(0.82–1.20)	.94	0.98	(0.81–1.18)	.82	0.97	(0.79–1.18)	.73
≥9 hours	0.99	(0.75–1.30)	.95	0.98	(0.74–1.28)	.86	0.99	(0.75–1.31)	.95	0.97	(0.74–1.28)	.83	0.98	(0.74–1.30)	.89
Adverse parental health behaviors															
≤6 hours	1.10	(1.00–1.22)	.06	1.06	(0.96–1.18)	.23	1.06	(0.96–1.17)	.26	1.04	(0.94–1.15)	.46	1.04	(0.94–1.16)	.45
≥9 hours	0.97	(0.84–1.13)	.73	0.96	(0.83–1.12)	.61	0.99	(0.83–1.11)	.56	0.95	(0.82–1.11)	.52	0.95	(0.81–1.11)	.51
Low socioeconomic status															
≤6 hours	1.04	(0.96–1.13)	.31	0.99	(0.91–1.08)	.88	1.02	(0.94–1.11)	.62	0.99	(0.91–1.08)	.79	0.98	(0.90–1.07)	.72
≥9 hours	1.04	(0.94–1.15)	.47	1.02	(0.91–1.13)	.78	1.03	(0.93–1.14)	.62	1.01	(0.91–1.13)	.85	1.02	(0.91–1.14)	.77
Combined childhood adversity															
≤6 hours	1.05	(1.00–1.11)	.05	1.02	(0.97–1.08)	.45	1.03	(0.98–1.09)	.28	1.01	(0.95–1.07)	.74			
≥9 hours	1.02	(0.95–1.09)	.66	1.00	(0.93–1.07)	.98	1.00	(0.94–1.08)	.90	0.99	(0.92–1.07)	.83			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations were reduced non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 12

Imputed Linear Regression Analyses of the Associations Between Adverse Childhood Environment and Sleep Deficiency (n = 3,559)

	β	95% CI	R^2	p
Stressful life events				
Model 1	0.02	(-0.06-0.10)	.01	.59
Model 2	0.02	(-0.05-0.10)	.01	.56
Model 3	0.02	(-0.06-0.09)	.02	.71
Model 4	0.02	(-0.06-0.10)	.02	.67
Model 5	0.01	(-0.07-0.09)	.02	.74
Adverse emotional environment				
Model 1	0.00	(-0.05-0.05)	.01	.99
Model 2	0.00	(-0.05-0.05)	.01	.99
Model 3	-0.01	(-0.05-0.04)	.02	.83
Model 4	0.00	(-0.05-0.04)	.02	.85
Model 5	-0.01	(-0.06-0.04)	.02	.71
Adverse parental health behaviors				
Model 1	0.02	(-0.003-0.05)	.01	.09
Model 2	0.02	(-0.004-0.05)	.01	.10
Model 3	0.02	(-0.01-0.05)	.02	.13
Model 4	0.02	(-0.01-0.05)	.02	.12
Model 5	0.02	(-0.01-0.05)	.02	.12
Low socioeconomic status				
Model 1	0.00	(-0.02-0.02)	.01	.88
Model 2	0.00	(-0.02-0.02)	.01	.83
Model 3	0.00	(-0.02-0.02)	.02	.79
Model 4	0.00	(-0.02-0.02)	.02	.82
Model 5	-0.01	(-0.03-0.02)	.02	.60
Combined childhood adversity				
Model 1	0.01	(-0.01-0.02)	.01	.41
Model 2	0.01	(-0.01-0.02)	.01	.42
Model 3	0.00	(-0.01-0.02)	.02	.58
Model 4	0.00	(-0.01-0.02)	.02	.45
Model 5				

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations remained non-significant.

ADVERSE CHILDHOOD ENVIRONMENT AND SLEEP

Supplement Table 13

Imputed Ordinal Regression Analyses on the Associations Between Adverse Childhood Environment and Sleep Problems (n = 3,559)

	OR	95% CI	p
Stressful life events			
Model 1	1.09	(0.92–1.30)	.30
Model 2	1.09	(0.92–1.29)	.34
Model 3	1.06	(0.89–1.26)	.49
Model 4	1.05	(0.88–1.25)	.58
Model 5	1.04	(0.88–1.24)	.64
Adverse emotional environment			
Model 1	1.07	(0.96–1.20)	.21
Model 2	1.07	(0.96–1.20)	.22
Model 3	1.04	(0.93–1.16)	.51
Model 4	1.04	(0.93–1.16)	.50
Model 5	1.03	(0.92–1.15)	.61
Adverse parental health behaviors			
Model 1	1.05	(0.99–1.11)	.09
Model 2	1.05	(0.99–1.11)	.08
Model 3	1.03	(0.94–1.09)	.27
Model 4	1.04	(0.98–1.10)	.21
Model 5	1.04	(0.98–1.10)	.20
Low socioeconomic status			
Model 1	0.99	(0.95–1.03)	.65
Model 2	0.99	(0.94–1.03)	.59
Model 3	0.98	(0.94–1.03)	.49
Model 4	0.99	(0.94–1.03)	.58
Model 5	0.98	(0.94–1.03)	.50
Combined childhood adversity			
Model 1	1.02	(0.99–1.05)	.29
Model 2	1.02	(0.99–1.05)	.29
Model 3	1.01	(0.98–1.04)	.74
Model 4	1.01	(0.98–1.04)	.58
Model 5			

Note. Model 1 included age and gender; Model 2 included age, gender, education, working full-time, and irregular working times or shift work; Model 3 included age, gender, BMI, alcohol consumption, smoking, physical activity, depression and regular use of prescription drugs; Model 4 adjusted for all covariates; and Model 5 adjusted for all covariates and other domains of childhood risks (e.g. analyses on stressful life events are adjusted for the other risk domains: adverse emotional environment, adverse parental health behaviors and low childhood socioeconomic status). After adjusting the significance level for the number of analyses ($p=.05/15=.003$) all associations remained non-significant.