Long-term effects of pregnancy and childbirth on sleep satisfaction and duration of first-time and experienced mothers and fathers.

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Abstract

Study Objectives: To examine the changes in mothers' and fathers' sleep satisfaction and sleep duration across pre-pregnancy, pregnancy, and the postpartum period of up to six years after birth; it also sought to determine potential protective and risk factors for sleep during that time.

Methods: Participants in a large population-representative panel study from Germany reported sleep satisfaction and sleep duration in yearly interviews. During the observation period (2008–2015), 2,541 women and 2,118 men reported the birth of their first, second, or third child and provided longitudinal data for analysis. Fixed-effects regression models were used to analyze changes in sleep associated with childbirth.

Results: Sleep satisfaction and duration sharply declined with childbirth and reached a nadir during the first three months postpartum, with women more strongly affected (sleep satisfaction reduction compared with pre-pregnancy: women, 1.81 points on a 0 to 10 scale, d = 0.79 vs. men, 0.37 points, d = 0.16; sleep duration reduction compared with pre-pregnancy: women, 62 min, d = 0.90 vs. men, 13 min, d = 0.19). In both women and men, sleep satisfaction and duration did not fully recover for up to six years after the birth of their first child. Breastfeeding was associated with a slight decrease in maternal sleep satisfaction (0.72 points, d = 0.32) and duration (14 min, d = 0.21). Parental age, household income, and dual vs. single parenting were unrelated, or only very weakly related, to improved sleep.

Conclusion: Following the sharp decline in sleep satisfaction and duration in the first months postpartum, neither mothers' nor fathers' sleep fully recovers to pre-pregnancy levels up to six years after the birth of their first child.

Keywords: Pregnancy, Childbirth, Sleep Satisfaction, Sleep Duration, Postpartum, Development

Statement of Significance

The costs of having children include drastic short-term consequences for maternal sleep, with a nadir in sleep satisfaction and duration during the first three postpartum months. After the first child, neither mothers' nor fathers' sleep satisfaction or duration fully recovers, even when their children reach preschool age (4–6 years postpartum). Sleep effects are more pronounced in first-time parents compared with experienced parents, in mothers compared with fathers, and in breastfeeding compared to bottle-feeding mothers. Higher socio-economic status (household income) and psychosocial factors (dual vs. single parenting) do not appear to protect against these postpartum sleep changes.

Introduction

Poor sleep quality and insufficient sleep are highly prevalent during pregnancy and after childbirth [1-8]. Although sleep disturbances have been linked with adverse birth outcomes [9, 10] and poor postpartum mental health [3, 11-14], intra-individual changes in maternal and paternal sleep across pre-pregnancy, pregnancy, and the postpartum years remain poorly described.

Existing longitudinal studies have shown that from late pregnancy onwards, insomnia symptoms remain highly prevalent and sleep duration decreases [15, 16], with first-time mothers more strongly affected than those experiencing their second or third childbirth [3]. During late pregnancy, sleep onset insomnia symptoms are more prevalent compared to the postpartum period, whereas sleep maintenance insomnia symptoms are more prevalent postpartum than during pregnancy [16]. While paternal sleep is also affected, there are indications that maternal sleep is more highly fragmented [17], includes longer periods spent awake after sleep onset [18], and leads to greater neurobehavioral performance deficits, such as decreased psychomotor vigilance [17]. Slight improvements in sleep quality are typically reported around weeks 10–12 postpartum [3, 19] and, consistent with this, the percentage of mothers with insomnia symptoms decreases from approximately 60% at week 8 postpartum to 40% at two years postpartum [16]. However, the exact course of sleep recovery as individuals' parental roles mature is yet to be explored.

Further, little is known regarding the impact of protective and risk factors on sleep disturbances during pregnancy and the postpartum years; most previous research has considered the effects of breastfeeding on maternal sleep, with inconsistent findings. While one study showed greater sleep fragmentation among breastfeeding women [15], others have not found sleep duration or quality differences between women using different feeding methods [7], or even longer

sleep duration among breastfeeding mothers [20] (for a review see Montgomery-Downs and colleagues [21]).

The role of some commonplace socio-demographic and psychosocial variables have not been investigated in detail either. For example, the extent to which parental age and parity may play a role in amplifying or buffering the effect of pregnancy and childbirth on sleep. One would also expect that variables representing higher socio-economic status (higher household income, homeownership) would protect against sleep disturbance, insofar as they are known to decrease stress levels generally [22]. It also makes sense to reason that living with a partner (i.e. dual parenting vs. single parenting) may be protective. Compared with single parenting, dual parenting involves higher levels of direct, practical support that might protect sleep (e.g. the partner may assist with nocturnal feedings) and/or emotional support, which may decrease perception of stress and thereby protect sleep [23, 24]. Clarity on the role of these variables would help interpret the effect of pregnancy and childbirth on sleep within a socio-economical context.

Further limiting our current understanding of sleep during pregnancy and after childbirth is that most investigators have used convenience samples, while population-representative samples have rarely been assessed. Existing studies with representative samples have been based on cohorts of pregnant women from hospitals with a geographically limited catchment area [3, 16]; no previous study has been based on a sample representative of a whole nation's population.

Identifying the precise timing and trends in, and factors underlying, sleep changes during and after pregnancy, would inform the development of evidence-based interventions for preventing or ameliorating the effects of pregnancy and childbirth on parental sleep. In the present study, we aimed to address gaps in the literature by taking advantage of a large, longitudinal panel study that represents the entire adult German population and by analyzing

intra-individual change across time using fixed-effects regression models. First, we examined whether mothers' and fathers' sleep satisfaction and duration decrease across pre-pregnancy, pregnancy, and the postpartum periods, with the expectation that mothers' sleep satisfaction and duration would decline during pregnancy and reach a nadir during early postpartum, while fathers' sleep satisfaction and duration would not be affected during pregnancy and less strongly affected postpartum compared to mothers. Second, we determined whether and when mothers' and fathers' sleep satisfaction and duration improved following childbirth, with the expectation that sleep satisfaction and duration should have reached baseline levels, after controlling for age, by the time the child reached their preschool years (4–6 years postpartum). Finally, we examined the roles of potential protective and risk factors for mothers' and fathers' sleep satisfaction and duration during pregnancy and the postpartum years, including socio-demographic background variables (maternal and paternal age, parity, household income, and homeownership), infant feeding practices (breastfeeding), and psycho-social variables (dual vs. single parenting).

Methods

Database Source

The data were drawn from the German Socio-Economic Panel (SOEP; Version 32.1; German Institute for Economic Research), an ongoing, nationally-representative, longitudinal study of private households in Germany. All members of the selected households aged 18 years and older were asked to participate in yearly interviews. Households were initially chosen using a multistage random sampling technique with regional clustering; later, some refreshment samples were added to increase the sample size and maintain the representativeness of the data for the entire population of Germany. In addition, new household members (e.g., new partners or grown-up children) were invited to join the study and were also interviewed during the yearly

assessment sessions. To minimize attrition, individuals were followed even in cases of relocation or a split in the household.

We used the measures of sleep satisfaction and duration collected during the annual interviews for eight waves of the SOEP (2008 to 2015). Comprehensive information about data collection, design, participants, variables, and assessment procedures have been described elsewhere [25]. All data were collected by a professional fieldwork organization (Kantar Public, Munich). The interview methodology of the SOEP is based on a set of pre-tested questionnaires for households and individuals. Generally, an interviewer tries to obtain face-to-face interviews with all members of a given survey household. All participants provided informed consent; ethical permission was granted by the Scientific Advisory Board of DIW Berlin. Scientific use of the SOEP is available to universities and research institutes. There have been no previous publications using SOEP data addressing the topics presented herein.

Participants

The sample included 2,541 women and 2,118 men who reported the birth of their first, second, or third child during the study period, lived in Germany, and contributed longitudinal data (i.e., at least two available data points on either sleep satisfaction or sleep duration); mothers were on average 32.9 (*SD* = 5.69) years and fathers were on average 36.18 (*SD* = 6.39) years old; with an average of 5.1 data points per participant for sleep satisfaction (*SD* = 2.0) and 4.6 for sleep duration (*SD* = 1.6). Average parental age at the birth of the first child was 30.10 years (*SD* = 5.37) for mothers and 33.26 years (*SD* = 5.82) for fathers. During the observation period (2008–2015), a total of 2,128 participants reported the birth of their first child (54.37% mothers; 1,338 first-born children); 2,461 participants reported the birth of their second child (54.57% mothers; 1,495 second-born children); and 1,032 participants reported the birth of their third

child (54.55% mothers; 671 third-born children). Few participants reported the birth of their fourth to twelfth child. These were excluded from analyses once they reached the '*2 years before childbirth*' position with their fourth child ($N = 690$ for sleep satisfaction; $N = 656$ for sleep duration; see Supplemental Materials, Table S1 for coding of childbirth for statistical analyses). The total panel sample comprised N = 38,861 participants with longitudinal data on either sleep satisfaction or sleep duration. Descriptive statistics are reported in Table 1. Participant flow charts can be found in the supplemental material (see Supplemental Materials, Figures S1 & S2).

Measures

Childbirth biography. Childbirth biographies are provided by the SOEP for every participant with at least one successful interview. To generate childbirth biographies, all available SOEP data were used, including information from the biographical questionnaire completed when each participant entered the panel; new childbirth information was collected during annual interviews.

Sleep satisfaction and sleep duration were self-reported by participants during the annual interviews between 2008 and 2015 (sleep duration was not included in 2014 due to interview time constraints). To reduce respondent burden as much as possible, only a single item indicator of sleep satisfaction was used ("How satisfied are you with your sleep?"), which was rated on an 11-point scale ranging from 0 ("*totally unsatisfied*") to 10 ("*totally satisfied*"). This single item is strongly correlated with validated scales that measure sleep problems and discriminates between individuals affected vs. unaffected by sleep disturbance [26-28]. Sleep duration was assessed with two items: "How many hours do you sleep on average on a normal day during the working week?" and "How many hours do you sleep on a normal weekend day?" Implausibly low or high values were unusual (i.e. sleep duration <2 hours: 85 observations; sleep duration >12 hours: 290

observations) and were replaced by a value of 2 or 12 hours, respectively. A weighted composite score was calculated as an indicator of mean sleep duration (i.e., sleep duration = ([5 × work day sleep duration] + [2 × weekend sleep duration]) / 7).

Breastfeeding. Associations between breastfeeding and parental sleep were assessed in a subsample of parents who had their first child within the observation period (2008–2015). Information on primiparous mothers' breastfeeding was available for 1,799 parents regarding sleep satisfaction and for 1,581 parents regarding sleep duration. Whether children were exclusively breastfed, and for how long, was not asked. Up to three months after the birth of their first child, 74.48% of mothers were still breastfeeding; 48.91% of mothers were still breastfeeding when their child was four to six months old.

Household income, homeownership, and single parenting. Participants' average monthly household income after taxes was 2,829€ (*SD* = 1,467€) at the birth of the first child. Home-ownership was reported by 29.33% when their first child was born. Compared to parents living in flats let for rent, homeowners had considerably larger living spaces (M = 132.02 m^2, SD = 44.86 m^2 vs. M = 83.23 m^2, SD = 24.58 m^2, respectively; $p < .001$). Single parenting was defined as participants indicating that they lived alone with their child or children. Single parenthood after birth of the first child was reported by 6.11% of all primiparous parents (n = 130; 117 women and 13 men).

Statistical analyses

To analyze changes in sleep satisfaction and duration over the course of pregnancy and postpartum, we used fixed-effects models [29,] (for the same analytic approach using SOEP-data see Mata and colleagues) [30]. Fixed-effects models exclusively analyze within-individual variation, which avoids confounding of results by time-constant unobserved heterogeneity, such

as social origin or genetic differences in sleep satisfaction and habitual sleep duration. Thus, the participants' sleep satisfaction and duration after the birth of a child were compared to their own pre-childbirth sleep satisfaction and duration. Further, the models control for all other included predictors (e.g. effects of the second childbirth are controlled for effects of the first childbirth) and control variables including *participant-centered age* and *age-squared*, because sleep quality and duration decline with age [31, 32].

To calculate these fixed-effects models, the variable of time between interviews and childbirth was represented with 21 dummy variables (coded 0 or 1) within every measurement wave. Within one measurement wave, dummy variables 1–7, 8–14, and 15–21 represented the time between the interview and the births of the first, second, or third child, respectively. Thus, there were seven dummy variables per childbirth. The dummy codes for the first childbirth were: *Year 2 before 1st childbirth* = the participant's first child was born during the second year after that interview; *Year 1 before 1st childbirth* = the first child was born during the year after that interview; *Year 1 after 1st childbirth* = the first child was born during the year before that interview; *Year 2 after 1st childbirth* = the first child was born between 1 year and 2 years before that interview; *Year 3 after 1st childbirth* = the first child was born between 2 years and 3 years before that interview; *Years 4 to 6 after 1st childbirth* = the first child was born between 3 years and 6 years before that interview; *More than 6 years after 1st childbirth* = the first child was born more than 6 years before that interview. These seven predictors were mutually exclusive. The same coding procedure was used for the second and third childbirths (see Supplemental Materials, Table S1).

Several secondary (follow-up) analyses were conducted: (1) To analyze the changes in sleep satisfaction and duration across pregnancy and the first year after the birth of the first child

at a more fine-grained level, separate follow-up analyses were conducted with indicators for each of the three pregnancy trimesters and indicators for each of the four quarters of the first year after childbirth. This allowed studying the more detailed course of sleep satisfaction and duration over the trimesters of pregnancy and postpartum; (2) Further follow-up analyses were conducted using the birth of the first child to test potential protective or risk factors as time-varying covariates: breastfeeding, maternal and paternal age, household income, homeownership, and dual parenting (vs. single parenting). The analyses of the time-varying covariates related to risk and protective factors rely on comparisons between coefficients of fixed-effects regression models, which are derived from different subsets of participants.

All analyses were conducted using Stata Version 15 (College Station, Texas). All Cohen's *d* score effect-sizes were calculated based on the standard deviation of the full sample.

Sensitivity Analysis

As is the case in all linear fixed-effects models with longitudinal data, the effect on within-person change (i.e., regarding sleep satisfaction and duration) can only be calculated for participants who report variation in the outcome of interest over time[29]. In our case, variation in sleep satisfaction was reported by 89.98% of all participants (with 176,061 observations in total) and variation in sleep duration was reported by 86.21% of all participants (with 144,779 observations in total). In the entire sample, 3,848 participants did not report any change in sleep satisfaction and 4,864 participants did not report any change in sleep duration. For sensitivity analysis, all participants were assigned an artificial within-person change (i.e., a mean of 0.0 and a SD of 0.0001) so that all participants were included in the analyses. The results of this analysis (not shown) were identical to those of the sample reporting change in sleep satisfaction or sleep duration.

Further, we compared participants with only one measurement time point and those with more measurements (i.e., participants with longitudinal data that could be used for fixed-effects analyses). There were only small differences in sleep satisfaction (7.04 vs. 6.80, respectively) and sleep duration (7.23 hours vs. 7.17 hours, respectively; all *p*'s < .001). These differences were further reduced after accounting for between-groups age differences (sleep satisfaction: d = 0.04, $p < .001$; sleep duration: $d = 0.02$, $p = .11$); participants with only one observation were younger and more likely to have been newly recruited (i.e. in the most recently added wave; $p <$ .001). Thus, when age-differences were accounted for, sleep satisfaction and duration were highly similar between participants who were included and those who were excluded from the fixed-effects models.

Results

Descriptive analyses

Descriptive statistics are presented in Table 1, separately for women and men. On average, women reported slightly lower sleep satisfaction ($M = 6.65$ vs. $M = 6.98$, $d = 0.15$; $p <$ .001) and almost identical sleep duration compared with men (M = 7 h 9 min vs. M = 7 h 11 min, $d = 0.03$; $p < .001$). In both women and men, sleep satisfaction was worse, and sleep duration shorter, for participants reporting childbirth compared with those not reporting childbirth (women: $M = 6.58$ vs. $M = 6.66$, $d = 0.04$ and M = 7 h vs. M = 7 h 10 min, $d = 0.15$, respectively; men: $M = 6.97$ vs. $M = 7.03$, $d = 0.03$ and M = 6 h 59 min vs. M = 7 h 13 min, $d = 0.21$, respectively; all *p*'s < .01). Participant age was negatively correlated with sleep satisfaction, r = -.10, $p < .001$, and sleep duration, r = -.04, $p < .001$. Socio-economic status and homeownership were associated with sleep satisfaction and duration, although the differences between groups were very small. Participants above the median monthly household income (Mdn = 2,500€) showed slightly higher sleep satisfaction and slightly longer sleep duration compared with

participants below the median (sleep satisfaction: $M = 7.03$ vs. $M = 6.58$, $d = 0.20$, $p < .001$; sleep duration: $M = 7$ h 8 min vs. $M = 7$ h 12 min, $d = 0.06$; $p < .001$). Homeowners showed slightly higher sleep satisfaction and slightly longer sleep duration compared to non-homeowners (sleep satisfaction: $M = 6.94$ vs. $M = 6.65$, $d = 0.13$, $p < .001$; sleep duration: $M = 7$ h 7 min vs. $M = 7$ h 13 min, $d = 0.08$, $p < .001$).

Course of sleep satisfaction and duration across pregnancy and birth of the first, second, and third child, for mothers and fathers

Fixed-effects regression models showed that for mothers, sleep satisfaction decreased with pregnancy and postpartum compared with before pregnancy (all *p*'s < .001, see Table 2 and Figure 1). Compared with the penultimate interview before the respective childbirth, mothers' sleep satisfaction decreased by an average of 1.53 points on the 0 to 10 scale ($d = 0.67$) after the birth of their first child, 0.96 points ($d = 0.42$) after the second, and 1.15 points ($d = 0.51$) after the third. Mothers' sleep duration increased slightly during pregnancy (10 min., $d = 0.14$, $p < .01$) but decreased sharply after childbirth compared with before pregnancy; sleep duration decreased on average by 41 minutes ($d = 0.59$) after the first child, 39 minutes ($d = 0.58$) after the second, and 44 minutes ($d = 0.64$) after the third (all *p*'s < .001, see Table 2 and Figure 1). Four to six years after the birth of their first child, maternal sleep satisfaction and duration were still lower than pre-pregnancy, after controlling for age (0.95 scale points, $d = 0.42$ for sleep satisfaction and 22 min., $d = 0.32$ for sleep duration, all *p*'s < .001). The birth of the second and third children affected mothers' sleep satisfaction significantly less than did the birth of the first child (all *p*'s < .001), while the effects on sleep duration were similar after the first, second, and third childbirth (all *p*'s >.05).

Consistent with mothers, fathers' sleep satisfaction and duration decreased after childbirth compared with before pregnancy ($p < .05$, see Table 2 and Figure 1) although compared with mothers these effects were significantly smaller (all p's < .001). An exception was fathers' sleep satisfaction after the birth of their third child, when sleep satisfaction no longer showed a significant decrease. In terms of effect sizes and compared to before pregnancy (i.e., at the second to last interview before the respective childbirth), fathers' sleep satisfaction decreased by $d = 0.18$ (0.41 scale points), $d = 0.09$ (0.20 points), and $d = 0.08$ (0.19 points) after the birth of their first, second, and third children. Moreover, fathers' sleep duration decreased on average by 14 minutes ($d = 0.21$), 9 minutes ($d = 0.13$), and 12 minutes ($d = 0.18$) after the first, second, and third child. Four to six years after the birth of their first child, fathers' sleep satisfaction and duration were still lower than their pre-pregnancy values (0.64 scale points, $d = 0.28$ for sleep satisfaction and 14 min, $d = 0.21$ for sleep duration, all p's < .01) after controlling for age. The birth of their second child affected fathers' sleep satisfaction less than did the birth of their first child (all p's < .05), while the effect on sleep duration was very similar after the first, second, and third childbirth.

Fine-grained analysis of sleep satisfaction and duration across the three pregnancy trimesters and first year after childbirth

Next, we conducted finer-grained analyses focusing on the first childbirth, with indicators for the last quarter year before pregnancy, each of the three pregnancy trimesters, and each of the four quarters of the first year after the child's birth (Figure 2 and Supplemental Materials, Tables S2-S5). There was a decrease in sleep satisfaction across the three pregnancy trimesters in women but not in men. There was no decrease in sleep duration across pregnancy in either women or men. However, there was a clear decrease in sleep satisfaction and duration between

the third pregnancy trimester and the first three months after childbirth in both women and men (all *p*'s < .001). In terms of the magnitude of change, compared to pre-pregnancy, sleep satisfaction was 1.81 scale points ($d = 0.79$) lower in women and 0.37 points ($d = 0.16$) lower in men; sleep duration was 62 minutes ($d = 0.90$) shorter in women and 13 minutes ($d = 0.19$) shorter in men. Compared to the third trimester of pregnancy, sleep satisfaction after childbirth was 0.57 points ($d = 0.25$) lower in women and 0.96 points ($d = 0.42$) lower in men; sleep duration was 87 minutes ($d = 1.27$) shorter in women and 27 minutes ($d = 0.40$) shorter in men. Between the first three-month quarter and the second three-month quarter after childbirth, both mothers' and fathers' sleep duration improved (all *p*'s < .001).

Potential protective and risk factors for mothers' and fathers' sleep satisfaction and duration across pregnancy and after the birth of their first child

Among the variables analyzed as potential protective or risk factors for parental sleep, maternal and paternal age, household income, and dual parenthood vs. single parenthood (for mothers) were unrelated to changes in either sleep satisfaction or duration across pregnancy and in the first year after birth of the first child (see Supplemental Materials, Tables S6-S9). However, breastfeeding slightly increased the negative effect of childbirth on sleep satisfaction and duration among mothers (0.72 points, $d = 0.32$ for sleep satisfaction; 14 min., $d = 0.21$ for sleep duration, all p's < .01) but not among fathers. Homeownership was associated with slightly better sleep satisfaction (0.27 points, $d = 0.12$) and slightly longer sleep duration (8 min., $d = 0.12$) in mothers.

Discussion

Our study shows, for the first time with a large population-representative panel study and a long-term follow-up of more than six years, that maternal sleep satisfaction decreases linearly

across the three trimesters of pregnancy and reaches a nadir during the first three months after birth; thereafter, maternal sleep satisfaction improves, though it does not reach pre-pregnancy levels even up to six years postpartum. Maternal sleep duration increases slightly during pregnancy, but in the first three months postpartum women experience, on average, a marked 1-hour reduction per night compared with pre-pregnancy. While sleep duration then increases by around 30 minutes, on average, during months 4–6 postpartum, it does not recover fully to pre-pregnancy levels even up to six years after the birth.

After the second and third child, the effects on maternal sleep satisfaction are less pronounced than after the first child. In contrast, maternal sleep duration shows a similar magnitude of change regardless of whether it was after the first, second, or third child. In sum, childbirth causes pervasive sleep effects for women despite being a common life-event. Most intriguingly, our study is the first to show that mothers' sleep satisfaction and duration do not recover to pre-pregnancy levels even up to six years after birth of the first child, having adjusted for maternal age.

Changes in paternal sleep satisfaction and duration after birth compared with pre-pregnancy are less pronounced and reach only around a third or less of the effects sizes seen in mothers. This may be associated with the observation that mothers, including working women, still have more household and child rearing responsibilities and spend more time on these tasks compared with fathers in most industrialized countries including Germany [33, 34] . It is possible that an unequal distribution of the burden of child nursing at night favoring fathers is reflected in a less pronounced decline in sleep satisfaction and sleep duration in fathers than mothers after childbirth. However, neither father's sleep satisfaction nor sleep duration reaches pre-pregnancy levels up to six years after the birth of their first child. Taken together, the long-term course of

348 both mothers' and fathers' sleep satisfaction and duration even up to six years following the birth
349 of their first child indicates incomplete recovery.

350 In line with previous research, our findings show a decrease in parental sleep satisfaction
351 during later pregnancy and immediately after childbirth [1-3, 6-8, 15, 16, 27], an improvement after the
352 first three postpartum months have passed in mothers [3, 19], more pronounced effects in mothers
353 compared with fathers [17, 18], and more pronounced effects after the first compared with the
354 second and third child [3]. The nadir of mothers' sleep satisfaction and duration during the first
355 three months after childbirth coincides with the peak in infant crying [35]. It is possible that
356 children's increased fussing and crying during the first three months after birth, along with their
357 dependence on frequent nocturnal feedings and other caretaking, are important reasons for
358 parental sleep disturbance after childbirth. Apart from infant crying and frequent nursing, other
359 potential proximate causes of poor postpartum sleep may involve physical pain following
360 delivery and distress related to the demands of a new role. Causes of the long-term decrease in
361 sleep satisfaction and duration till six years after birth may involve changes in duties, strains, and
362 worries related to the parental role even when children are older.

363 One aim of our study was to examine the roles of several potential factors that may be
364 protective of maternal and paternal sleep during pregnancy and postpartum. Our study shows that
365 breastfeeding is related to a slight decrease in maternal sleep satisfaction (0.72 points on the 0 to
366 10 scale, $d = 0.33$) and duration (14 min, $d = 0.21$). This finding adds further evidence to the
367 long-standing question about whether breastfeeding is related to sleep quality, for which
368 previous research has yielded inconsistent findings. Our results are consistent with a study
369 showing more sleep fragmentation among breastfeeding women [15] but they are also in contrast to
370 studies showing no differences in sleep between breastfeeding and non-breastfeeding women [36]

371 or even longer sleep duration in breastfeeding mothers [20]. It is possible that these inconsistent
372 findings are due to differences in sample selection. While other studies have examined sleep in
373 convenience samples, the current study included a large sample representative of the adult
374 population in Germany. Further, it is possible that inconsistent findings are due to differences in
375 measurement of sleep (e.g., self-report vs. actigraphy).

376 Towards determining other factors that may protect maternal and paternal sleep
377 satisfaction and duration, we studied socio-demographic (parental age), socio-economic
378 (household income, homeownership), and psychosocial (dual vs. single parenting) factors.
379 Among these, only homeownership emerged as a significant factor for mothers' sleep; however,
380 the effect size was very modest. Our examination of potential protective factors therefore
381 suggests that wealthier parents, parents who are older, and mothers who live with a partner are
382 equally vulnerable to the sleep-impairing effects of pregnancy and childbirth as are less wealthy,
383 younger, and single counterparts.

384 While our study has important strengths, including our examination of a large
385 representative sample and analysis of sleep patterns longitudinally from pre-pregnancy through
386 pregnancy and until six years after childbirth, it also includes some limitations. First, only single-
387 item survey questions were administered. Although there is evidence for reliability and validity
388 of single-item questions about sleep satisfaction and duration [27, 37, 38] - and objective sleep
389 recordings with samples of this size are impractical - employing objective measures of sleep may
390 nonetheless have strengthened our study. Moreover, it is possible that more sensitive measures of
391 psychosocial support during pregnancy and the postpartum years may have revealed more
392 protective effects on sleep. Relatedly, we could not distinguish between exclusive breastfeeding
393 and breastfeeding supplemented by formula or infants receiving breast milk from the bottle.

Second, it is possible that other variables which were not analyzed herein may have moderated the effect of childbirth on sleep, such as bed-sharing (co-sleeping with the infant), duration of family leave, or body mass index. Third, due to the study design, only yearly assessment waves are available. This precludes analysis of changes in sleep across the trimesters of pregnancy and the postpartum quarters in a pure longitudinal analysis. Fourth, while our study shows within-individual changes across time that coincide with pregnancy and childbirth, this does not preclude the possibility that other, unobserved causal mechanisms may have been involved. Finally, it is impossible to exclude the possibility that panel dropout was non-random, which may have affected effect sizes and interpretation of the findings. While sensitivity analyses indicated that there were no sleep differences between participants who continued or dropped out, it is possible that changes in sleep may have occurred after the last interview.

In conclusion, our study shows that pregnancy, and particularly the first several months postpartum, are accompanied by a marked decline in parental sleep satisfaction. This is especially true for first-time mothers, for whom childbirth is presumably the most significantly sleep-altering life event during their adulthood. After the birth of a first child, sleep satisfaction apparently does not fully recover to pre-pregnancy levels in either mothers or fathers. It is therefore possible that parenthood contributes meaningfully to the well-documented overall decline in sleep satisfaction during adulthood [31, 32]. We found little evidence for factors that might offset the impacts of pregnancy and childbirth on parental sleep. Higher socio-economic status and dual parenting do not buffer against the decrease in either sleep satisfaction or duration, while breastfeeding and living in a rented flat appear to only slightly amplify the effect on maternal sleep during the first three months postpartum. Because sleep plays an important role for adjustment and mental health during pregnancy and postpartum, it is an important task

for future research to examine ways to protect sleep quality and duration in this stage of the life cycle. Furthermore, advice and support should be routinely provided for new parents preparing for childbirth, towards managing their postpartum sleep expectations and to encourage them to take precautions to reduce risks from the effects of sleep fragmentation and deprivation.

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Figure captions

Figure 1. *Sleep satisfaction standardized based on overall sample (A, B, C) and sleep duration in hours (D, E, F) of mothers and fathers during years 2 and 1 before birth and during years 1, 2, 3, and 4-6 following birth of the first (A, D), second (B, E), and third child (C, F). The approximate time of birth is indicated by a vertical line. Error bars represent 95% confidence intervals of fixed-effects regression coefficients.*

Figure 2. *Sleep satisfaction standardized based on overall sample (A) and sleep duration in hours (B) for women and men before pregnancy (tri0: trimester 0 including months 1-3 before pregnancy), during pregnancy (tri1: months 1-3 of pregnancy; tri2: months 4-6 of pregnancy; tri3: months 7-9 of pregnancy), and during the first year of the firstborns life (quart1: months 1-3 after childbirth; quart2: months 4-6 after childbirth; quart3: months 7-9 after childbirth; quart4: months 10-12 after childbirth). The approximate time of birth is indicated by a vertical line. Error bars represent 95% confidence intervals of fixed-effects regression coefficients. Note that neighboring confidence intervals are generated by different subsets of participants.*

Appendix captions

Coding procedure for first, second, and third childbirth

Table 1. *Demographic information on participants in the analysis sample.*

	Total	Men reporting no childbirth in study period	Fathers reporting childbirth in study period [b]	Women reporting no childbirth in study period	Mothers reporting childbirth in study period [b]
Number of Participants [a]	38,861	15,837	2,118	18,365	2,541
Number of Observations [a]	190,227	76,655	10,657	89,889	13,026
Age M (SD)	48.77 (17.29)	50.98 (17.67)	36.18 (6.39)	50.68 (17.15)	32.90 (5.69)
% Partner lives in same household	69.43	70.89	94.87	62.59	87.22
Educational attainment					
% Low (ISCED: 0,1,2)	14.28	11.83	9.41	17.47	10.60
% Middle (ISCED: 3,4)	56.11	53.93	52.67	58.35	56.32
% High (ISCED: 5,6)	29.61	34.24	37.92	24.18	33.09
Home ownership (%)	52.12	56.75	42.42	51.30	38.43
Household income after taxes in EUR/month M (SD)	2,942 (1,968)	3,044 (2,053)	3,200 (1,613)	2,812 (1,968)	3,027 (1,638)
Number of participants with sleep satisfaction data (analysis sample for sleep satisfaction)	38,428	15,657	2,097	18,165	2,509
Number of observations regarding sleep satisfaction	186,507	75,052	10,519	88,110	12,826
Number of observations per participant regarding sleep satisfaction M (SD)	4.85 (2.26)	4.79 (2.33)	5.02 (2.02)	4.85 (2.27)	5.11 (2.00)
Sleep satisfaction M (SD)	6.80 (2.27)	6.97 (2.21)	7.03 (2.03)	6.66 (2.35)	6.57 (2.23)
Number of participants with sleep duration data (analysis sample for sleep duration)	35,272	14,326	1,864	16,817	2,265
Number of observations regarding sleep duration	159,802	64,791	8,483	76,206	10,322
Number of observations per participant regarding sleep duration M (SD)	4.53 (1.82)	4.52 (1.87)	4.55 (1.58)	4.53 (1.83)	4.55 (1.56)
Sleep duration M (SD)	7.17 (1.14)	7.21 (1.11)	6.99 (0.93)	7.17 (1.19)	7.00 (1.11)

Note.

[a] This number includes participants with longitudinal data on either sleep satisfaction or sleep duration making it larger than the two analysis samples.

[b] This refers to participants reporting the birth of their 1st, 2nd, or 3rd child.

ISCED: International Standard Classification of Education, a statistical framework for organizing information on education maintained by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Table 2. *Fixed-effects estimates predicting sleep satisfaction and sleep duration in hours with separate regression analyses for men and women.*

	Sleep satisfaction (unstandardized)		Sleep satisfaction (standardized)		Sleep duration (unstandardized)		Sleep duration (standardized)	
	Men	Women	Men	Women	Men	Women	Men	Women
Person-centered age	-0.041***	-0.042***	-0.018***	-0.018***	-0.019***	-0.029***	-0.017***	-0.025***
	(0.003)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Person-centered age squared	0.003*	0.002	0.001*	0.001	0.002*	0.002*	0.001*	0.001*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Year 2 before 1st childbirth	0.105	0.136	0.046	0.060	-0.025	0.055	-0.022	0.048
	(0.109)	(0.106)	(0.048)	(0.047)	(0.055)	(0.053)	(0.048)	(0.047)
Year 1 before 1st childbirth	0.078	-0.456***	0.034	-0.200***	0.047	0.164**	0.041	0.144**
	(0.102)	(0.101)	(0.045)	(0.044)	(0.056)	(0.055)	(0.049)	(0.048)
Year 1 after 1st childbirth	-0.414***	-1.533***	-0.182***	-0.674***	-0.240***	-0.676***	-0.210***	-0.592***
	(0.095)	(0.093)	(0.042)	(0.041)	(0.051)	(0.050)	(0.045)	(0.044)
Year 2 after 1st childbirth	-0.496***	-1.117***	-0.218***	-0.491***	-0.252***	-0.425***	-0.220***	-0.373***
	(0.101)	(0.099)	(0.045)	(0.043)	(0.055)	(0.053)	(0.048)	(0.047)
Year 3 after 1st childbirth	-0.561***	-0.976***	-0.247***	-0.429***	-0.230***	-0.386***	-0.201***	-0.338***
	(0.108)	(0.105)	(0.048)	(0.046)	(0.058)	(0.056)	(0.051)	(0.049)
Years 4 to 6 after 1st childbirth	-0.641***	-0.951***	-0.282***	-0.418***	-0.241***	-0.365***	-0.211***	-0.319***
	(0.110)	(0.106)	(0.048)	(0.047)	(0.059)	(0.057)	(0.052)	(0.050)
More than 6 years after 1st childbirth	-0.423***	-0.682***	-0.186***	-0.300***	-0.220**	-0.321***	-0.193**	-0.281***
	(0.128)	(0.125)	(0.056)	(0.055)	(0.069)	(0.068)	(0.061)	(0.059)
Year 2 before 2nd childbirth	0.037	0.030	0.016	0.013	0.041	0.067	0.036	0.059
	(0.099)	(0.095)	(0.044)	(0.042)	(0.050)	(0.048)	(0.044)	(0.042)
Year 1 before 2nd childbirth	0.130	-0.021	0.057	-0.009	0.003	0.061	0.003	0.053
	(0.099)	(0.095)	(0.044)	(0.042)	(0.054)	(0.051)	(0.047)	(0.045)
Year 1 after 2nd childbirth	-0.198*	-0.962***	-0.087*	-0.423***	-0.143**	-0.656***	-0.125**	-0.575***
	(0.099)	(0.094)	(0.043)	(0.041)	(0.054)	(0.051)	(0.047)	(0.045)
Year 2 after 2nd childbirth	-0.221*	-0.437***	-0.097*	-0.192***	-0.087	-0.367***	-0.077	-0.322***
	(0.105)	(0.100)	(0.046)	(0.044)	(0.057)	(0.054)	(0.050)	(0.047)
Year 3 after 2nd childbirth	-0.064	-0.133	-0.028	-0.059	-0.090	-0.201***	-0.079	-0.176***
	(0.111)	(0.105)	(0.049)	(0.046)	(0.060)	(0.057)	(0.053)	(0.050)

Years 4 to 6 after 2nd childbirth	0.086	0.088	0.038	0.039	-0.029	-0.098	-0.026	-0.086
	(0.111)	(0.105)	(0.049)	(0.046)	(0.060)	(0.057)	(0.053)	(0.050)
More than 6 years after 2nd childbirth	0.122	0.186	0.054	0.082	0.034	-0.004	0.030	-0.004
	(0.131)	(0.127)	(0.058)	(0.056)	(0.072)	(0.069)	(0.063)	(0.060)
Year 2 before 3rd childbirth	0.076	-0.226	0.033	-0.099	0.121	-0.122	0.106	-0.107
	(0.140)	(0.133)	(0.062)	(0.059)	(0.070)	(0.067)	(0.061)	(0.059)
Year 1 before 3rd childbirth	0.138	-0.224	0.061	-0.098	0.022	0.014	0.019	0.012
	(0.137)	(0.130)	(0.060)	(0.057)	(0.074)	(0.072)	(0.065)	(0.063)
Year 1 after 3rd childbirth	-0.190	-1.154***	-0.084	-0.508***	-0.203**	-0.728***	-0.178**	-0.637***
	(0.129)	(0.125)	(0.057)	(0.055)	(0.071)	(0.069)	(0.062)	(0.060)
Year 2 after 3rd childbirth	-0.223	-0.830***	-0.098	-0.365***	-0.123	-0.446***	-0.108	-0.390***
	(0.139)	(0.135)	(0.061)	(0.059)	(0.075)	(0.073)	(0.066)	(0.064)
Year 3 after 3rd childbirth	-0.293	-0.352*	-0.129	-0.155*	-0.175*	-0.310***	-0.153*	-0.271***
	(0.150)	(0.145)	(0.066)	(0.064)	(0.081)	(0.079)	(0.071)	(0.069)
Years 4 to 6 after 3rd childbirth	-0.310*	-0.366*	-0.136*	-0.161*	-0.138	-0.223**	-0.121	-0.195**
	(0.149)	(0.144)	(0.066)	(0.064)	(0.081)	(0.079)	(0.071)	(0.069)
More than 6 years after 3rd childbirth	-0.184	-0.115	-0.081	-0.051	-0.185	-0.191	-0.162	-0.168
	(0.197)	(0.193)	(0.087)	(0.085)	(0.108)	(0.106)	(0.094)	(0.093)
Constant	7.199***	7.102***	0.176***	0.133***	7.324***	7.431***	0.136***	0.229***
	(0.072)	(0.088)	(0.032)	(0.039)	(0.040)	(0.049)	(0.035)	(0.043)
Observations	85,571	100,936	85,571	100,936	73,274	86,528	73,274	86,528
Participants	17,754	20,674	17,754	20,674	16,190	19,082	16,190	19,082

Note.

Analyses are based on a total of 186,507 observations from 38,428 participants for sleep satisfaction and 159,802 observations from 35,272 participants for sleep duration (see Supplemental Material, Figures S1 & S2). Standardization is based on these overall samples.

Standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1. *Sleep satisfaction standardized based on overall sample (A, B, C) and sleep duration in hours (D, E, F) of mothers and fathers during years 2 and 1 before birth and during years 1, 2, 3, and 4-6 following birth of the first (A, D), second (B, E), and third child (C, F). The approximate time of birth is indicated by a vertical line. Error bars represent 95% confidence intervals of fixed-effects regression coefficients.*

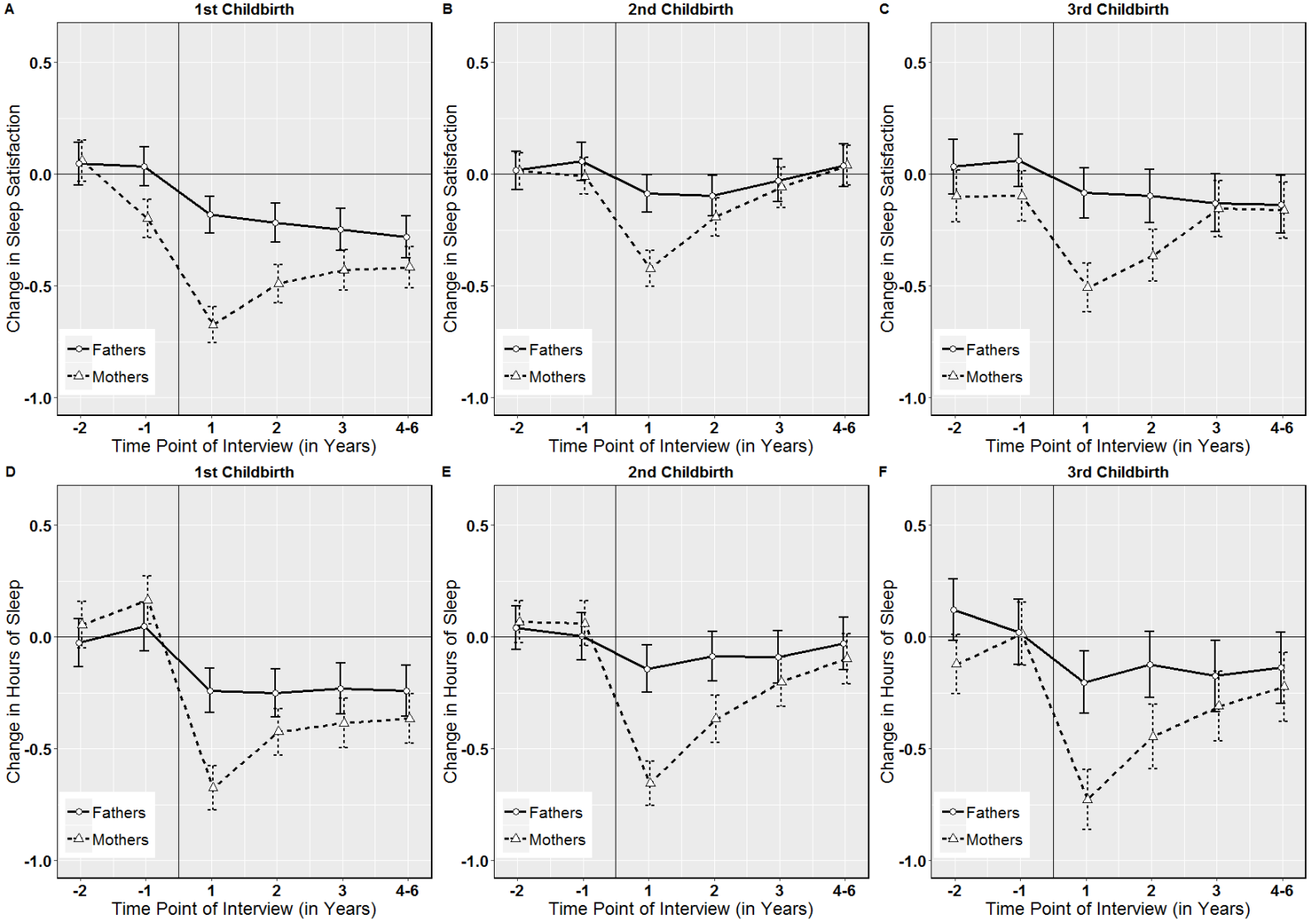

Figure 2. *Sleep satisfaction standardized based on overall sample (A) and sleep duration in hours (B) for women and men before pregnancy (tri0: trimester 0 including months 1-3 before pregnancy), during pregnancy (tri1: months 1-3 of pregnancy; tri2: months 4-6 of pregnancy; tri3: months 7-9 of pregnancy), and during the first year of the firstborns life (quart1: months 1-3 after childbirth; quart2: months 4-6 after childbirth; quart3: months 7-9 after childbirth; quart4: months 10-12 after childbirth). The approximate time of birth is indicated by a vertical line. Error bars represent 95% confidence intervals of fixed-effects regression coefficients. Note that neighboring confidence intervals are generated by different subsets of participants.*