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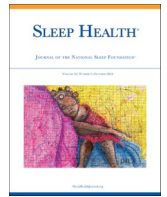


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Intrafamilial associations of sleep multitrajectory groups between ages of 3 and 60 months in the SEPAGES cohort

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ABSTRACT

Objectives: We investigated intrafamilial sleep evolution by identifying children's sleep multitrajectory groups between 3- and 60-month of age and their association with parental sleep multitrajectory groups. **Methods:** We included 180 children from the SEPAGES cohort (Grenoble, France) whose parents belonged to previously identified sleep multitrajectory groups, through group-based multitrajectory modeling, between 3 and 36 months postpartum, using nighttime (NSD) and weekend daytime (DSD) sleep durations and subjective sleep loss, comprising "No," "Subjective," and "Global" sleep problems groups. Child sleep information (NSD, DSD, subjective sleep loss, night waking, and sleep onset difficulties) was collected by parental questionnaires at 3-, 12-, 36-, and 60-month. We identified sleep multitrajectory groups using group-based multitrajectory modeling in children and examined their associations with parental sleep multitrajectory groups using multinomial logistic regressions.

Results: We identified three sleep multitrajectory groups in children: the "No/few" group (29.4%) had moderate NSD, long DSD, low subjective sleep loss/night waking/sleep onset difficulties prevalence, the "Moderate" group (60.0%) had long NSD and moderate DSD, and medium subjective sleep loss/night waking/sleep onset difficulties prevalence, and the "Global" group (10.6%) had the shortest NSD and DSD, and the highest subjective sleep loss/night waking/sleep onset difficulties prevalence. After adjusting for covariates, mothers in the "Global" group were more likely to have children in the same group, and mothers in "Subjective" and "Global" groups were less likely to have children in the "Moderate" group than in the "No/few" group. No association was identified with paternal or couple sleep multitrajectory groups.

Conclusions: The observed associations between parent-child sleep multitrajectory groups suggest greater maternal sensitivity to or involvement in the child's sleep than the fathers. Early preventive sleep actions could improve sleep in children and mothers.

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Introduction

The optimal sleep duration for children varies according to their age, and the recommended total sleep duration decreases as children get older. The recommended total sleep duration is 12h–16h/24h between 4 and 12 months. It decreases to 11h–14h/24h between 1 and 2 years, and to 10h–13h/24h for children aged 3 to 5 years.¹

Nighttime and daytime sleep are differentiated from 3 months onwards, and the daytime sleep duration gradually decreases throughout childhood, generally stopping by the age of 6.² Sleep problems, such as night waking (NW) and sleep onset difficulties (SOD), defined as sleep latencies of more than 30 minutes, are common in young children. Birth cohorts have shown that around 20% of infants have more than two NW in the first year of life³ and that half of the preschoolers wake up at least once a night.² Similarly, in birth-cohorts, the prevalence of SOD varies from 10% to 25% in the first 2 years of life.^{4,5} Parents' subjective perception of their child's sleep loss (SSL), that is, the child's sleep deprivation or lack of sleep as perceived by parents, has never been studied as such in the pediatric population, although it could be a marker of the match

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between the child's needs and actual sleep when sleep is reported by parents and not objectively measured.

A systematic review summarizing 46 studies suggests that sociodemographic factors, such as higher parental education attainment and family income, are associated with longer sleep duration and fewer sleep problems in children.⁶ Furthermore, repeated cross-sectional analyses in a cohort study suggested that children living in poverty were more likely to have insufficient sleep from 6 months to 8 years than those who had never experienced this condition⁷ and that maternal age greater than 35 years at the time of pregnancy was negatively associated with sleep quantity and quality from 6 months to 11 years.² In addition, child-related factors such as childhood obesity at around 20 months,⁸ male sex² and the presence of early sleep practices, such as requiring the parental presence to fall asleep and cosleeping in a same bed or room during the first year of life^{5,8} or among preschoolers under 5 year-old,^{9,10} were reported to be cross-sectionally linked to poor sleep quantity and/or quality in children.

Studies on intrafamilial sleep, that is, studying the relations between parents' sleep and their child's sleep, have focused on associations between infant and maternal sleep characteristics in the early postnatal period and thereafter, suggesting that maternal sleep patterns are associated with infant subjective and objective sleep-wake pattern for 4 to 10 weeks postpartum^{11,12} and with infant sleep problems such as NW and later bedtimes during the first year postpartum.¹³ A cross-cultural cross-sectional study found that maternal and child sleep, reported by mothers, were associated in terms of bedtime, waketime, number of NW and total nighttime sleep.¹⁴ In addition, mothers have reported greater changes in their sleep (quantity and quality) than fathers,¹⁵⁻¹⁹ while both mothers and fathers suffered from sleep disturbances up to a year after delivery.^{16,18,19} Researchers have attempted to determine the direction of intrafamilial sleep associations. For example, a meta-analysis by Varma et al suggests that children's sleep disturbances have an impact on their parents' sleep rather than vice-versa.¹⁵ On the other hand, studies have suggested that parents' sleep practices toward their child (i.e., having bedtime routines or cosleeping in one's bed/room) were associated with children's later sleep characteristics,^{20,21} suggesting either child- or parent-centered factors may influence other family members.

Previous studies have limitations. First, most studies focused on mother-child pairs.^{11-13,22} Despite the increased attention paid to paternal sleep or paternal influence in the family context,²³⁻²⁵ paternal sleep has only been considered in a few cross-sectional^{16,26} and longitudinal studies with short follow-up.^{18,19} Thus, longitudinal studies including both parents and the child with a prolonged follow-up are needed to gain greater insight into the interrelationships and dynamics of intrafamilial sleep in the first years. Second, most studies have focused on sleep durations defined either by global means or by using predefined thresholds, typically those recommended by sleep societies. Sleep problems, such as frequent NW or SOD, have been less studied, but they have also been defined by global prevalence. However, these global measures do not provide information on the diversity of changes in population sleep characteristics over time. Finally, previous studies have observed sleep characteristics one by one, even though they may not be independent. Thus, studies including simultaneously multiple sleep measures of mothers, fathers, and children over several months or years and identifying groups of similar longitudinal sleep profiles would be informative in the understanding of the intrafamilial sleep dynamic over the studied period.

Therefore, this study aimed to analyze the evolution of sleep characteristics within families and more particularly the interrelations between longitudinal changes in sleep of mother-child, father-child, and couple-child pairs between 3 and 60 months. In particular, our aims were to identify multitrajectory groups of sleep in

children using a multitrajectory modeling method and to study their associations with previously identified multitrajectory groups of sleep of mothers, fathers, and couples.²⁷ This was an exploratory study, however, given the existing literature, we expected to observe (i) similarities in sleep multitrajectory characteristics (e.g., relatively shorter sleep duration or higher prevalence of SSL) in the associated groups of sleep multitrajectories when studying associations between mother-child, father-child or couple-child multitrajectory groups, that is, children who sleep poorly would be more likely to have parents who also sleep poorly, and vice versa and (ii) stronger associations between mother-child multitrajectory groups than between father-child or couple-child multitrajectory groups.

Methods

Study design

The SEPAGES cohort (Suivi de l'Exposition à la Pollution Atmosphérique durant la Grossesse et Effet sur la Santé, <https://cohort-sepages.fr/en>) aims to characterize exposure to environmental contaminants and its influence on the health of pregnant women, fetuses, and children. The cohort details have been previously published.²⁸ Briefly, 2321 pregnant mothers who were at less than 19 gestational weeks, older than 18 years old, having a singleton pregnancy, living in the Grenoble area (France) and planning to give birth in one of the four maternities clinics involved in the study were eligible. 484 mothers agreed to participate, and their male partners were included when he was older than 18 years old, has social insurance and agreed to participate (N = 410). Finally, their children (N = 471) were registered for the cohort. Data were collected in the first or at the very beginning of the second trimester of pregnancy and regularly up to 60 months.

Participating parents signed consent for themselves and their children. SEPAGES study obtained approval from the CPP (Comité de Protection des Personnes Sud-Est V) and the Commission Nationale de l'Informatique et des Libertés (CNIL), the French data privacy institution.²⁸

Data

Main measures for children's sleep trajectories modeling

Parental self-questionnaires were used to collect information on children's sleep at 3, 12, 36, and 60 months of age. Usual bedtime and wake up time were asked for weekday and weekend day at each time-point by the questions "What time do you usually put your child to bed at night (6 PM to midnight)?" and "What time does he/she wake up in the morning?" Usual daytime sleep duration on weekdays and weekends was collected using two questions "Does your child nap? (Y/N)" and "What is the total duration of naps (adding up all the nap durations in a day)?" Mean night and day sleep durations (NSD and DSD, respectively) for the whole week were calculated in hours and minutes. Subjective sleep loss (SSL) reflects parents' view on how much sleep their child is getting, whether they think their child is getting enough sleep or not, and was collected by the following question: "Do you think your child is sleep-deprived? (Never, sometimes, often and always or almost always)." NW information was collected by the following question: "How many nights has your child woken up this week? (Never or almost, sometimes, around once in 2 nights, almost every night)." SOD was collected by the following question "When you put your child to bed, does he/she have difficulties falling asleep? For example, does he/she call or cry for a long time (more than 30 minutes)? (Never, sometimes, often and always or almost always)." The presence of frequent SSL was considered when the answers were "often" or "always or almost always," and the presence of frequent NW and SOD was considered when the answers were "around once

in 2 nights” and “almost every night” for NW, and “often” and “always or almost always” for SOD according to the literature.²⁹

Thus, the child sleep characteristics used to create the groups are those that globally characterize young children’s sleep (i.e., NSD, DSD, NW, and SOD). These sleep characteristics have already been used in previous work on children aged 1 to 5.5 years, and have made it possible to identify several groups of children with specific sleep characteristics.²¹ In the present work, parental perception of child’s SSL was added, as it could be a marker of the adequacy between the child’s needs and actual sleep.

Maternal and paternal sleep multitrajectory groups

The identification of the parental sleep multitrajectory groups has been previously published.²⁷ Briefly, parental information on usual sleep was collected at 3, 18, 24, and 36 months postpartum. It included night sleep duration (NSD) obtained with the question “What time do you go to bed?” and “What time do you wake up?” for weekdays and weekends; Usual daytime sleep duration on weekdays and weekends was collected using two questions: “Do you nap? (Y/N)” and “What is the total duration of naps (add all nap duration in a day)?” and SSL obtained by the question “Do you think you are sleep-deprived? (Y/N).” Mean nocturnal sleep duration (NSD) for the whole week was calculated in hours and minutes. Since most postpartum mothers and fathers did not nap during weekdays, but in weekends only weekend DSD (in hours and minutes) was further taken into account. Among the 188 couples with available sleep data at least 2 out of the 4 time points between 3 and 36 months postpartum (Fig. 1), the minimum information required to model groups of sleep multitrajectories using the same methods as described in IL-3.1, we identified three groups of maternal (Fig. 2A), paternal (Fig. 2B), and couple (Fig. 2C) sleep trajectories. Comparing groups with each other, we found that one group was characterized by a relatively long NSD, a short DSD, and a low prevalence of SSL. We called it the “No” sleep problem groups of mothers or fathers; another group was characterized by a relatively long NSD, medium-long DSD, and a medium-high prevalence of SSL called the “Subjective” sleep problems groups of mothers or fathers; and a final group was characterized by the shortest NSD, medium-long DSD,

and a medium-high prevalence of SSL, called the “Global” sleep problems groups of mothers or fathers.

Covariates

Information was collected during pregnancy at study inclusion, at delivery and up to 12 months after childbirth.

Socioeconomic, demographic, and parental factors were collected at inclusion for both mother and father: level of education (below bachelor level, Y/N), work during pregnancy (Y/N), professional qualification (Laborer, intermediate profession, and executive or higher intellectual profession), age at conception, and prepregnancy BMI. Nationality (European or not) was also collected but not accounted for because of low variability (only 2 individuals were of non-European origin). The Hospital Anxiety and Depression scale (HAD) was used to estimate the presence of anxiety or depressive symptoms in the 2nd trimester of pregnancy for fathers and the 3rd trimester for mothers. A score ≥ 8 was considered the presence of anxious or depressive symptoms. Maternal and paternal chronotype were estimated by the Munich Chronotype Questionnaire³⁰ at 1 year postpartum and corresponded to mid-sleep time accounting for sleep jet lag between weekday and weekend day. Finally, the early child’s characteristics were collected at birth from parental-reported questionnaires and the medical record, including the delivery method (cesarean section or vaginal delivery), sex, birth term (weeks), birth weight (kg), and being a first child (Y/N). Childbirth seasonality was estimated based on the month of birth and classified as spring (Mar-May), summer (Jun-Aug), autumn (Sep-Nov), and winter (Dec-Feb). Information on breastfeeding as collected at age 2, 18, 24, and 48 weeks after birth and dichotomized as breastfed for ≥ 26 weeks according to the WHO recommendation³¹ (Y/N). Child sucking behavior (sucking pacifier only, sucking finger only, sucking both and sucking nothing) and sleep practices (bouncing to get asleep, feeding to get asleep, child sleeping alone, room sharing with other people when sleeping, parental presence to get asleep) (Y/N) were collected at 3 months old. Tobacco use, either maternal smoking during pregnancy or child passive smoking up to 6 months (Y/N), and child main daycare at 6 months (at home individual care, out-of-home individual care, collective care) was also collected.

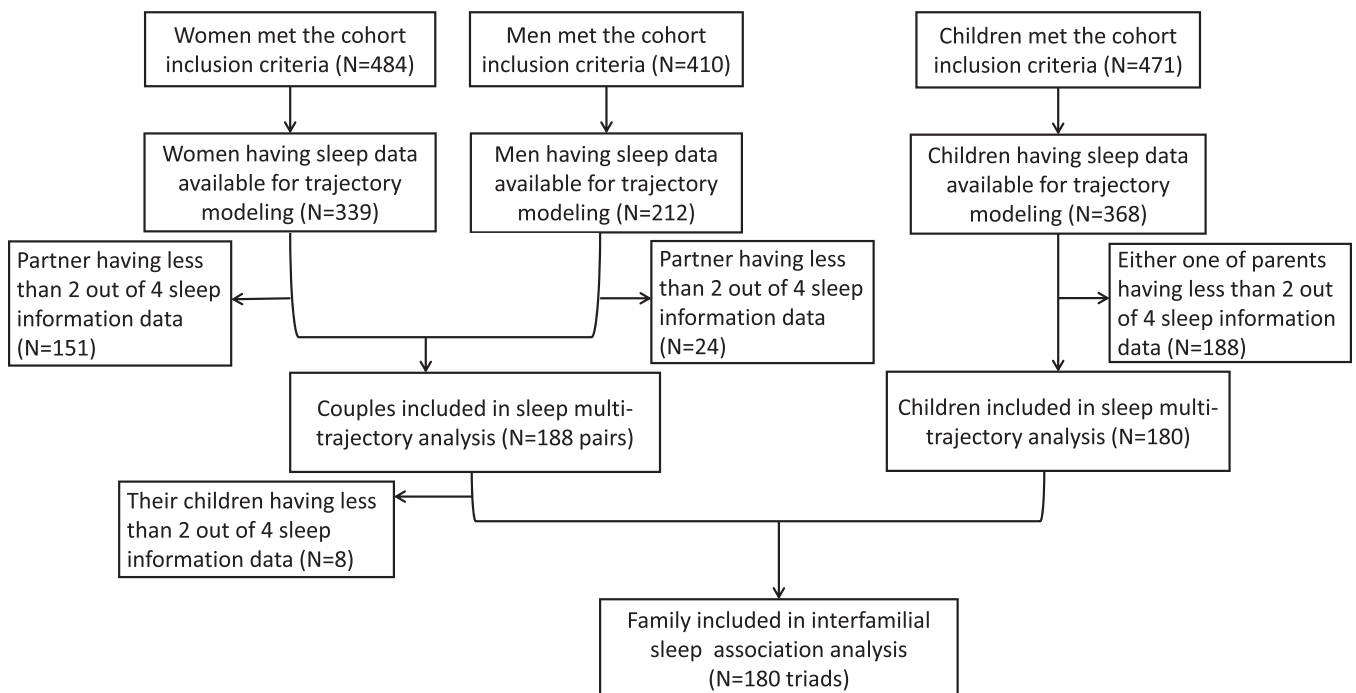
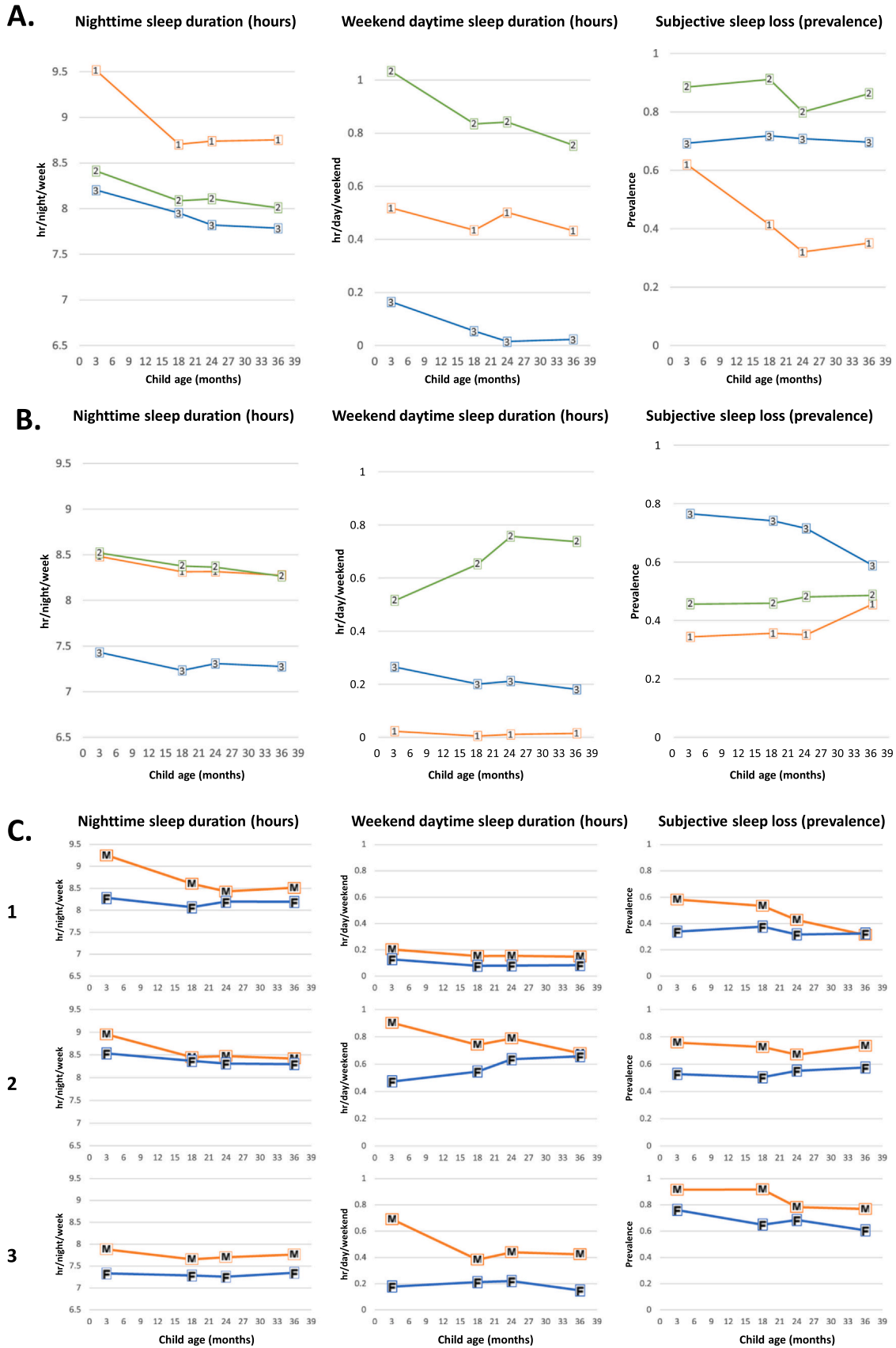


Fig. 1. Flowchart of the population



(caption on next page)

Fig. 2. Parents' sleep multitrajectories from Nature and Science of Sleep 2024 16 247-261'. Originally published by and used with permission from Dove Medical Press Ltd. (A) Maternal sleep multitrajectories obtained in the SEPAGES cohort between 3 and 36 months postpartum. 1: No sleep problems (N = 91, 48.4%), 2: Subjective sleep problems (N = 61, 32.4%), 3: Global sleep problems (N = 36, 19.1%). Lines represent mean nighttime and weekend daytime sleep duration and prevalence of subjective sleep loss trajectories. (B) Paternal sleep multitrajectories obtained from the SEPAGES cohort between 3 and 36 months postpartum. 1: No sleep problems (N = 69, 36.7%), 2: Subjective sleep problems (N = 84, 44.7%), 3: Global sleep problems (N = 35, 18.6%). Lines represent mean nighttime and weekend daytime sleep duration and prevalence of subjective sleep loss trajectories. (C) Couple sleep multitrajectories obtained from the SEPAGES cohort between 3 and 36 months postpartum. 1: No sleep problems (N = 53, 28.2%), 2: Subjective sleep problems (N = 54, 28.7%), 3: Global sleep problems (N = 81, 43.1%). Circles indicate maternal multitrajectories and squares indicate paternal multitrajectories. Lines represent mean nighttime and weekend daytime sleep duration and prevalence of subjective sleep loss trajectories

Statistical method

All statistical analysis was performed by using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Multitrajectory modeling

Child sleep multitrajectory groups were identified using group-based multitrajectory modeling method (GBMTM, PROC TRAJ procedure) developed by Nagin et al.,^{32,33} including NSD, DSD, SSL, NW, and SOD between 3 and 60 months of age. GBMTM is a longitudinal data-based clustering method identifying groups of individuals following a similar evolution of an outcome (sleep in this study) across several indicators (NSD, DSD, SSL, NW, and SOD in this study). The individual responses are used to calculate model parameters and the probabilities of belonging to each group of trajectories, according to the maximum likelihood method.³³ GBMTM allows for missing values, and each child was included in the multitrajectory modeling (N = 180) if information on sleep characteristics was available at least at 2 out of 4 time points collected (N = 368) and if both parents were already assigned to a multitrajectory sleep group (N = 188) in the previous study.²⁷ Different models from 2 to 5 multitrajectory groups were computed. The best-fitting model was selected based on Bayesian Information Criteria (BIC) and was verified according to the recommended criteria: the average probability of belonging to each trajectory (≥ 0.7), the odds of correct classification (≥ 5) and the similarity between the model's estimations of the multitrajectory prevalence and the actual prevalence.³² Each child was assigned to the sleep multitrajectory group to which he/she had the highest probability of belonging to. In sensitivity analyses, multitrajectory modeling was rerun on the full sample of children (N = 368) who had sleep information available at 2 out of 4 time points, regardless of the availability of their parental sleep information.

Interrelations between children and maternal/paternal sleep multitrajectory groups

Associations between children and maternal, paternal or couple sleep multitrajectory groups were assessed using multinomial regression analyses. In all analyses, the chosen reference group was the one the closest to the recommended sleep duration in childhood or adulthood and lowest prevalence of frequent SSL, NW, or SOD.

Confounding factors considered in the association analysis were identified on the basis of a directed-acyclic graph (DAG, www.dagitty.net).³⁴ However, to limit the number of included factors, only those associated either with child, maternal, paternal, or couple sleep multitrajectory with a p -value $< .10$ in bivariate analyses were included in adjusted models. Therefore, maternal and paternal education level, maternal anxiety and depressive symptom, maternal and paternal chronotype, smoking, childbirth seasonality, first child, child sex and sleep practices at 3 months (bouncing to get asleep, feeding to get asleep, parental presence to fall asleep) were included in adjusted models.

Multiple imputation with fully conditional specification (SAS 9.4: MI procedure, FCS option) was used to impute missing covariate data (4.9%) on a variable-by-variable basis, nominal and ordinal variables were imputed by multinomial logistic regression, and continuous variables by linear regression. Twenty datasets were established and analyzed. Pooled effect estimates were calculated (SAS 9.4:

MIANALYSE procedure) based on Rubin's rules. Level of significance was defined as a p -value $< .05$.

Sensitivity analyses were conducted to assess the associations between multitrajectory sleep groups of mothers and children, identified from the maximum sample with sleep data (N = 317 dyads), adjusting for the same covariates.

Results

Sample characteristics

Among the 471 children included in the cohort at birth, 103 did not have sleep information at least 2 out of 4 time points for sleep multitrajectory modeling, and 188 children did not have parents with previously identified sleep multitrajectories,²⁷ mostly due to low rate of paternal response (Fig. 1). Table 1 shows the characteristics of the 180 mother-father-child triads analyzed for the present study. Compared to nonanalytic children (N = 291), analytic children were less likely to need parental presence to fall asleep (30.2% vs. 41.0%, $p = .04$). Analytic mothers were more likely to be in executive or higher intellectual profession (56.3% vs. 47.1%, $p = .04$) and analytic fathers tended to have earlier chronotype (3h12 vs. 3h30, $p = .03$). Other maternal, paternal and child characteristics did not differ between analytic and nonanalytic individuals.

Information available on children's sleep at each time point are presented in Appendix A and the children's overall sleep characteristics of the analytic sample are shown in Table 2. Briefly, the mean NSD increased from 10h14 to 11h07 between 3 and 12 months, then slightly decreased to 10h44 at 36 months, remaining stable at 60 months while the mean DSD decreased continuously from 3h46 to 20 minutes from 3 to 60 months. SSL prevalence increased from 6.9% to 20.9% between 3 and 60 months, while NW prevalence decreased from 60.9% to 9.8% on the same period and SOD prevalence fluctuated, being lowest at age 12 months (6.5%) and highest at age 36 months (21.0%). Correlation matrices of sleep characteristics are provided in Appendix B.

Child sleep multitrajectory groups identification

Three groups of sleep multitrajectories were identified among the 180 children. NSD, DSD, and SOD trajectories followed a quadratic shape in all groups. SSL and NW trajectories were best modeled by linear relationship for the first and second trajectory groups and cubic relationship for the third trajectory group (Fig. 3). To name the different groups, we used internal comparisons, that is, we used comparisons between the groups themselves, particularly with regard to sleep durations, as they were generally within the limits of international recommendations. Thus, "relatively short" and "relatively long" durations refer to relative durations in our sample and do not refer to the recommendations of the Sleep Societies.

The first group of children ("No/few" sleep problems, N = 53, 29.4%) had a relatively short NSD of 9h00 at 3 months of age, which increased largely to 11h12 at 12 months and then decreased to 10h58 between the ages of 36 and 60 months. The DSD was relatively long and decreasing from 4h24 at 3 months to 23 minutes at 60 months. Prevalence of frequent SSL was low at 3 and 12 months (0.2%) rising to 7.5% at 36 months and 9.7% at 60 months. In this group, prevalence of frequent NW decreased from 47.4% at 3 months

Table 1
Characteristics of analytical sample (N = 180 children)

		Included% (N) or mean (SD) (N = 180)	Excluded % (N) or mean (SD) (N = 290)	p-value ^a	N missing
<i>Parental demographic factors</i>					
Maternal European nationality	Yes	98.9 (173)	100 (246)	.09	5
Paternal European nationality	Yes	98.9 (172)	99.2 (119)	.79	6
Maternal highest diploma ≥ bachelor	Yes	86.0 (154)	80.9 (245)	.15	1
Paternal highest diploma ≥ bachelor	Yes	82.8 (144)	78.3 (94)	.34	6
Mother working during pregnancy	Yes	88.1 (156)	87.6 (233)	.86	3
Father working during pregnancy	Yes	100.0 (190)	100.0 (112)	-	0
Maternal work qualification during pregnancy	Executive or higher intellectual profession	56.3 (89)	47.1 (105)	.04	22
	Intermediate profession	18.4 (29)	15.2 (34)		
	Laborer	25.3 (40)	37.7 (84)		
Paternal work qualification during pregnancy	Executive or higher intellectual profession	72.3 (112)	63.2 (67)	.16	25
	Intermediate profession	16.1 (25)	17.0 (18)		
	Laborer and employee	11.6 (18)	19.8 (21)		
<i>Parental characteristics</i>					
Maternal age at conception		32.8 (3.5)	32.3 (4.1)	.23	0
Paternal age at conception		35.5 (4.2)	35.1 (4.7)	.55	21
Maternal preconceptional BMI		22.0 (3.3)	22.6 (4)	.09	1
Paternal preconceptional BMI		23.8 (3.7)	24.8 (3.5)	<.01	1
Maternal anxiety and depressive symptoms during pregnancy	Yes	37.1 (66)	39.2 (103)	.66	0
Paternal anxiety and depressive symptoms during pregnancy	Yes	22.5 (39)	32.7 (37)	.06	7
Mother lived in couple during pregnancy	Yes	99.4 (179)	98.7 (300)	.42	0
Delivery method	C-section	14.4 (26)	18.4 (55)	.26	0
	Vaginal delivery	85.6 (154)	81.6 (244)		
Maternal chronotype ^a		3h00 (0h36)	3h06 (0h36)	.28	48
Paternal chronotype ^a		3h12 (0h42)	3h30 (0h42)	.03	33
Maternal tobacco uses during pregnancy or child passive smoking	Yes	23.9 (43)	21.5 (62)	.55	0
<i>Child characteristics</i>					
Gestation age (wk)		39.3 (1.5)	39.2 (1.7)	.89	0
Birth weight (kg)		3.3 (0.4)	3.3 (0.5)	.75	0
Childbirth seasonality	Spring	17.8 (32)	22.7 (68)	.29	0
	Summer	27.8 (50)	28.3 (85)		
	Autumn	33.9 (61)	26.3 (79)		
	Winter	20.6 (37)	22.7 (68)		
Breastfed ≥26 wk	Yes	54.9 (96)	51.5 (137)	.49	5
First child	Yes	45.6 (82)	46.1 (140)	.92	0
Child sex	Boy	56.1 (101)	52.2 (156)	.40	0
<i>Other characteristics</i>					
Child sucking behavior at 3 mo	Both	25.0 (41)	26.9 (47)	.76	
	Pacifier only	26.2 (43)	29.7 (52)		16
	Finger only	29.3 (48)	27.4 (48)		
	Nothing	19.5 (32)	16.0 (28)		
Child daycare at 6 mo	At home individual care	46.7 (79)	38.9 (75)	.31	11
	Out-of-home individual care	36.1 (61)	42.5 (82)		
	Collective care	17.2 (29)	18.7 (36)		
<i>Child sleep practices</i>					
Bouncing to get asleep at 3 mo	Yes	39.5 (64)	40.0 (70)	.93	18
Feeding to get asleep at 3 mo	Yes	38.5 (62)	39.4 (69)	.86	19
Child starting and finishing night in one's own bed at 3 mo	Yes	59.1 (94)	52.8 (85)	.25	21
Child sharing room at 3 mo	Yes	46.3 (76)	36.6 (64)	.07	16
Parental presence to get asleep at 3 mo	Yes	30.2 (49)	41.0 (71)	.04	18

Abbreviation: BMI, body mass index.

^a p-values are based on chi-squared tests for binary or categorical variables, and t tests for continuous variables. Values < .05 are considered statistically significant.^a Chronotypes correspond to mid-sleep time accounting for sleep jet lag between weekday and weekend day.

to 0.7% at 36 months and then remained stable. Prevalence of frequent SOD was relatively low and showed a sharp decrease from 18.2% to 5.7% between the ages of 3 and 12 months, then remaining stable until 60 months of age. Considering the total sleep duration and generally low prevalence of frequent SSL, NW, and SOD, this group was chosen as reference for the further analysis.

The second group of children (“Moderate” sleep problems, N = 108, 60.0%) had a relatively long NSD of around 10h50 with a peak at 11h12 at age 12 months and showed a decreasing DSD from 3h26 at 3 months to 22 minutes at 60 months. This second group had also low sleep problems prevalence, but higher than the “No/

few” sleep problems group: Prevalence of frequent SSL prevalence increased from ≈5.0% between 3 to 12 months to 20.4% at 60 months, prevalence of frequent NW decreased from 61.2% to 11.1% between 3 and 60 months and prevalence of frequent SOD was around 10% but peaked at 22.5% at 36 months.

The third group of children (“Global” sleep problems, N = 19, 10.6%) had the shortest NSD. It rose from 9h18 to 10h22 between the ages of 3 and 12 months, then decreased to 10h02 at 60 months. DSD decreased rapidly from 4h07 at 3 months to 5 minutes at 60 months. This third group had the highest prevalence of sleep problems. Prevalence of frequent SSL rose from 28.7% at 3 months to

Table 2
Children's sleep characteristics at each time point (N = 180)

	Nighttime sleep duration		Daytime sleep duration		Subjective sleep loss	Night waking	Sleep onset difficulty
	N	Mean (SD; range)	N	Mean (SD; range)	Freq % (N)	Freq % (N)	Freq % (N)
3 m	159	10h14 (1h16; 7h00-13h30)	148	3h46 (1h38; 0h30-8h30)	6.9 (11)	60.9 (100)	16.0 (26)
12 m	163	11h07 (0h41; 9h00-13h30)	163	2h37 (0h51; 0h45-6h12)	8.9 (15)	34.3 (58)	6.5 (11)
36 m	160	10h44 (0h33; 8h00-12h30)	131	1h49 (0h32; 0h00-3h15)	17.5 (31)	20.9 (37)	21.0 (37)
60 m	146	10h45 (0h35; 5h00-11h49)	141	0h20 (0h37; 0h00-3h17)	20.9 (32)	9.8 (15)	12.4 (19)

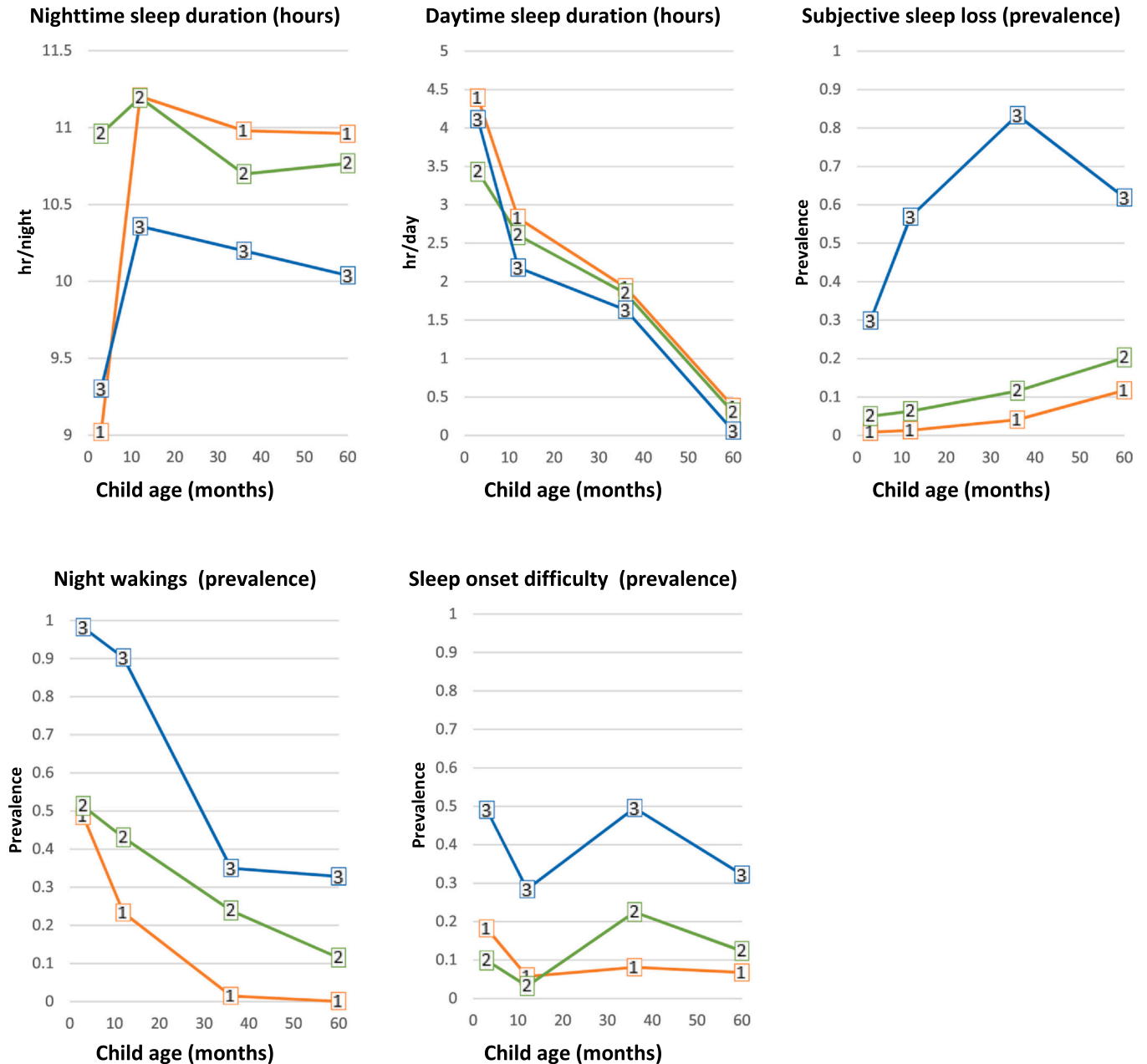


Fig. 3. Children's sleep multitrajectories obtained from the SEPAGES cohort between 3 and 60 months. 1: No/few sleep problems (N = 53, 29.4%), 2: Moderate sleep problems (N = 108, 60.0%), 3: Global sleep problems (N = 19, 10.6%). Lines represent mean nighttime and daytime sleep duration and prevalence of subjective sleep loss, night waking and sleep onset difficulties trajectories

82.4% at 36 months, before decreasing to 62.3% at 60 months. Prevalence of frequent NW was very high at 3 months (99.9%) but decreased to 32.3% at 60 months. Prevalence of frequent SOD fluctuated, being around ≈49% at 3 and 36 months and around ≈30% at 12 and 60 months.

The sensitivity analysis among the entire sample of children (N = 368) modeled similar sleep multitrajectory groups to those in the main analysis. However, compared to the main analysis, the "Global" sleep problems group included more children (17.3% vs. 10.5% in the main analysis) along with shorter NSD (8h30 vs. 9h20)

Table 3 Unadjusted and adjusted interrelations between children and maternal, paternal or couple sleep multitrajectory groups (N = 180 triads)

Sleep problem groups	Mothers						Fathers						Couples					
	Unadjusted		Adjusted		Global		Unadjusted		Adjusted		Global		Unadjusted		Adjusted		Global	
	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global	Subjective	Global
Children	0.49 [0.28-0.88]	0.45 [0.22-0.92]	0.50 [0.27-0.92]	0.35 [0.14-0.87]	1.27 [0.77-2.10]	0.82 [0.48-1.38]	1.28 [0.69-2.38]	0.85 [0.54-1.33]	0.85 [0.41-1.78]	0.85 [0.54-1.33]	0.85 [0.41-1.78]	0.85 [0.54-1.33]	0.85 [0.41-1.78]	0.85 [0.54-1.33]	1.04 [0.51-2.15]	0.85 [0.05-1.45]	1.01 [0.49-2.10]	1.01 [0.49-2.10]
Global	2.18 [1.04-4.60]	2.15 [1.00-4.62]	2.20 [0.94-5.15]	3.32 [1.25-8.82]	0.56 [0.27-1.16]	0.95 [0.44-2.07]	0.59 [0.25-1.39]	1.03 [0.55-1.91]	1.10 [0.38-3.18]	1.03 [0.55-1.91]	1.10 [0.38-3.18]	1.03 [0.55-1.91]	1.08 [0.49-2.37]	0.90 [0.29-2.77]	0.90 [0.29-2.77]	1.67 [0.55-5.02]	1.67 [0.55-5.02]	1.67 [0.55-5.02]

Reference groups for adults are “No sleep problem” groups (OR and 95% CI in bracket). Adjusted models included maternal and paternal education level, maternal anxiety and depressive symptom, maternal and paternal chronotype, smoking, childbirth seasonality, first child, child sex and sleep practices at 3 months (bouncing to get asleep, feeding to get asleep, parental presence to get asleep). Significant interrelations ($p < .05$) are bolded.

and DSD (2h50 vs. 4h07) at age 3 months of age but a lower prevalence of frequent SSL, NW, and SOD from 3 to 60 months (Appendix C).

Interrelations between parent and child sleep multitrajectory groups

Distribution of children’s sleep multitrajectory groups by mother’s, father’s or couple’s sleep multitrajectory groups is provided in Appendix D and factors associated with each sleep multitrajectory group in bivariate analysis ($p < .10$) are provided in Appendix E. Briefly, compared with the “No/few” sleep problems group, the factors associated with a higher risk of the child belonging to the “Global” sleep problems group were the highest maternal diploma (above bachelor’s level), the presence of symptoms of maternal anxiety or depression during pregnancy, being a male child, being born in autumn (compared with summer) and being the first child. Sleep practices (need for parental presence, bouncing and feeding to fall asleep) were also associated with a higher risk of the child belonging to the “Global” sleep problems group. No factors were associated with the “Moderate” sleep problems group compared with the “No/few” sleep problems group in children. Compared with the “No” sleep problems group, the factors associated with higher or lower risks in mothers and fathers belonging to the “Global” sleep problems groups were few and different. No factors were associated with mothers or fathers belonging to the “Subjective” sleep problems groups (Appendix E).

Associations between child and both maternal, paternal and couple sleep multitrajectory groups are presented in Table 3. In the adjusted models, compared to mothers in the “No” sleep problems group, mothers in the “Global” sleep problems and the “Subjective” sleep problem groups were less likely to have children in the “Moderate” sleep problems group than in the “No/few” sleep problems group. Also, mothers in the “Global” and the “Subjective” sleep problems group were more likely to have children in the “Global” sleep problem group than in the “No/few” sleep problems group, although the significance is borderline for mothers in the “Subjective” sleep problems group.

The sensitivity analysis among the larger sample of mothers and children (N = 317 dyads) showed the similar results (Appendix F).

Discussion

Understanding how sleep characteristics evolve in the family context is an important step in developing good sleep practices for children and their parents in the postpartum period and beyond. In this study, we show the interrelations of three groups of sleep multitrajectories in children, characterizing the changes in the child’s sleep between 3 and 60 months, with parental sleep, and more specifically with the maternal sleep multitrajectories previously identified in the French SEPAGES birth-cohort.²⁷

Most previous studies focused either on sleep quantity^{2,8,35,36} or sleep problems, especially NWS.^{37,38} Meanwhile, only one study has identified multitrajectory groups of sleep characteristics in children including NSD, DSD, NW, and SOD between the ages of 1 to 5.5 years, in the French ELFE birth cohort (N = 9273 children).²¹ The ELFE cohort’s large sample size enabled identification of five sleep groups, which may be more precise in differentiating sleep characteristics between groups than the present study. However, we identified similar groups of child good sleepers (“No/few” sleep problems and “Good” sleepers in the SEPAGES study, “Good sleepers but few SOD” and “Long sleepers” in the ELFE study), intermediate sleepers (“Moderate” sleep problems in the SEPAGES study and “Improving NW and SOD” in the ELFE study) and poor sleepers (“Global” sleep problems in the SEPAGES study and “Persistent NW and SOD” in the ELFE study). The proportion of children belonging to the poor sleeping group was lower in the SEPAGES cohort than in the

ELFE cohort (10.6% vs. 17.5%). This could possibly be explained by higher socioeconomic level and better health practices such as longer breastfeeding duration in the SEPAGES cohort, which may reflect families who have sufficient resources to be likely to follow healthy lifestyle recommendations.³⁹ The present study adds information on sleep characteristics before the age of 12 months, which is missing in the ELFE cohort, and shows a high prevalence of frequent NW at 3 months, 60.9% in the overall sample, but 98% in the “Global” sleep problems group. This, combined with high SOD frequency and short sleep duration in this latter group, highlights the high risk of sleep disturbances persistence from early infancy to toddlerhood and childhood.²¹ This persistence of sleep disturbances has also been suggested by longitudinal trajectory modeling studies in children aged 3 to 66 months and focusing on each sleep characteristic separately (NSD, DSD, NW, or SOD) in Singapore,³⁵ Australia,⁴⁰ and France.³⁸

While other longitudinal studies focused either on nighttime sleep duration^{11,13} or problems^{16,22} one by one, we identified associations between child and maternal sleep multitrajectory groups but not between child and paternal or couple sleep multitrajectory groups from the ages of 3 to 36 months. Our results are in accordance with the literature reporting that child short sleep duration¹⁴ or frequent NW¹⁶ was predictor of short maternal sleep duration, lower subjective sleep quality¹⁶ or frequent NW²² up to 2 years, while no¹⁸ or less¹⁶ correlation was reported between child sleep problems and paternal sleep quality. Indeed, while meeting the recommendations for optimal total sleep duration for age, children in the “No/few” sleep problems group had 2 hours less NSD and similar DSD, SSL, and SOD at age 3 months than children in the “Moderate” sleep problems group, but a lower frequency of NW and SOD at age 36 months. However, compared with children belonging to the “No/few” sleep problems group, children belonging to the “Moderate” sleep problems group were less likely to have mothers belonging to sleep groups with problems. This suggests that the sleep characteristics of the very young child have a stronger link with maternal sleep up to 36 months than the child’s sleep characteristics later on.

The association we observed may be explained by several factors and behaviors. First, in general young adult population, women are reported to be both more sensitive to sleep disturbances⁴¹ and to have longer wake after sleep onset compared to men⁴² suggesting that women’s sleep could be more easily disrupted by external causes such as child sleep arousal. In addition, paternal sleep modification up to 12 months reported by both parents¹⁸ or 26 months postpartum when measured objectively¹⁶ has been reported to be less associated with child sleep. Also, fathers are reported to be less sensitive to, or to show higher tolerance to distressed children’s signals than mothers up to 29 months postpartum²⁴, and mothers had stronger belief than fathers that they must immediately respond to their child at night during the first year of postpartum,⁴³ which may result in more disturbed sleep among mothers. Third, it has been repeatedly reported that mothers are more involved in nighttime child caring than fathers up to 29 months postpartum.^{15–17,22,44} and we suggest that this tendency may continue up to 36 months postpartum as shown in our study. Indeed, in the same sample, we previously suggested that mothers are more prone to adapt their sleep to their environment.²⁷

On the other hand, studies have shown that parental factors can also have an impact on children’s sleep. Sleep characteristics have been reported to be hereditary, that is, genetically determined (about 45%), with heritability varying with age (from 17% in infancy to 69% in adolescence).⁴⁵ However, this cannot explain the differences observed between fathers and mothers in the present study. Other parental factors and habits may play a more important role. For example, children with bedtime routines in infancy and preschool were reported to have better sleep duration and quality.²⁰

Early sleep practices, such as parental presence and feeding to fall asleep, as well as sleeping at least part of the night out of one’s own bed at age one, have been associated with children’s sleep outcomes up to age 5,²¹ suggesting that early sleep practices may have a longitudinally impact on children’s sleep outcomes. We also observed that several sleep practices at 3 months (i.e., need for parental presence, bouncing and feeding to fall asleep) were associated with the child belonging to the “Global” sleep problems group (Appendix E), which reinforces the hypothesis. However, these factors were taken into account in the present analyses. In addition, it has also been suggested that greater parental knowledge of their child’s sleep is associated with better sleep outcomes in children.^{26,43} Given that mothers are generally the main caregivers of children, may have a greater influence on the children’s care and therefore on their sleep. Nevertheless, several studies identified association between higher paternal involvement in nighttime child caring and decrease in both paternal- and maternal-reported child sleep problems^{44,46} and increased child and maternal sleep consolidation during 3 to 6 months after birth.⁴⁷ Those results suggest that paternal nighttime childcaring involvement could be a preventive factor for their offspring and partner’s sleep.

This study has several strengths. First, the prospective cohort design with repeated follow-up from 3 to 60 months postpartum allowed us to reduce memory bias and improve accuracy in the sleep reports. Second, the use of GBMTM³³ method allowed longitudinal analysis of child sleep patterns from 3 to 60 months postpartum by accounting simultaneously for multiple measures of sleep quantity (NSD, DSD, and SSL) and quality (NW and SOD) allowing for a better characterization of children’s overall sleep patterns over time. This was also the case for the maternal and paternal sleep characterization.²⁷ Third, GBMTM methods allowed inclusion of missing data and we included children with sleep data available at least at 2 out of 4-time point measurements to maximize the study sample size. Fourth, to our knowledge, this is the first study to report parents’ subjective assessment of their child’s lack of sleep (SSL). The frequency of positive responses increased with the child’s age but was only higher for children belonging to the “global sleep problem” group than for children belonging to other groups, and could therefore be a good indicator for screening children. However, this will need confirmatory studies.

Nevertheless, this study has limitations. First, approximately 61% of the cohort population was excluded due to the restriction of the analysis to children whose parents had available sleep multitrajectories. This restriction mainly led to the exclusion of children with the most severe sleep disturbances, as shown by the sensitivity analysis and resulted in a small size for the “Global” sleep problems group (N = 19). However, despite this restriction, we were able to observe associations between children with poor sleep and their mother’s sleep, and the sensitivity analysis including a larger sample of mothers and children yielded the same associations and effect sizes, strengthening our confidence in the obtained results.

Second, information on child’s sleep was collected by self-administered questionnaires to parents and may therefore be more reflective of the parents’ perception of their child’s sleep than of the child’s actual sleep. Both parents could have completed the child’s sleep questionnaire at each given time, but we have no information on who did. A systematic review including fathers and children from birth to 12 years found that the poor child sleep was negatively associated with paternal sleep when sleep was measured either by objective measures or paternal report.²⁴ Other studies including fathers and mothers additionally showed smaller associations between father-child pairs than mother-child pairs when sleep was reported by both maternal and paternal reports¹⁶ or objectively measured.¹⁸ In our study, if the child sleep questionnaires were preferentially completed by mothers at the same time they completed their own questionnaire, this may partially

explain the stronger sleep interrelation between mother-child pair than between father-child pair. However, parental self-administered questionnaires, when completed by mothers, have been shown to be reliable compared to objective sleep measures in healthy children,⁴⁸ and are still used classically in pediatric sleep epidemiology.^{49,50}

Conclusion

This study provides both additional insight on the variability of childhood sleep quantity and quality evolution between the ages of 3 to 60 months and their relations with parental sleep up to 36 months postpartum. Using information, at four time points between the ages of 3 and 36 months, on nighttime and daytime sleep duration, frequent SSL, NW and SOD, we identified three groups of children: those with no/few sleep troubles, those with moderate sleep troubles and those with global sleep troubles. We also showed that having a child with moderate or global sleep troubles was associated with sleep in mothers, but not fathers. Therefore, promoting early preventive actions during pregnancy or the early postpartum period, including sleep hygiene and sleep habits in children, could improve sleep problems in children and mothers. Further, longitudinal studies are needed to confirm our findings, including information on fathers' sleep and their involvement in household chores and childcare, particularly at night, to better understand the relations between fathers' and children's sleep. In addition, further studies are warranted to investigate if the identified sleep multi-trajectory groups are predictive for subsequent cognitive, mental, or other physical health outcomes.

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Author contributions

MK: Formal analysis, Writing – original draft. **SLC:** Resources, Data curation, Writing – review & editing. **SB:** Resources, Writing – review & editing. **CP:** Resources, Data curation, Writing – review & editing. **SP:** Conceptualization, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of conflicts of interest

None.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.sleh.2024.07.011](https://doi.org/10.1016/j.sleh.2024.07.011).

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