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Sleep duration trajectories from age 3 to 48 months in The Pelotas (Brazil) 2004 Birth Cohort Study

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Abstract

Background: Optimal sleep is essential for child growth, development, and immune function. Few studies have evaluated factors associated with sleep duration in childhood from a longitudinal perspective.

Objectives: This study aimed to identify trajectories of sleep duration in childhood and associated maternal and child characteristics.

Methods: Sleep duration was assessed by maternal report at 3, 12, 24, and 48 months among children from the Pelotas (Brazil) 2004 Birth Cohort. Independent variables included family income, maternal and child demographics, and clinical characteristics. Trajectory analysis was carried out using a semi-parametric, group-based modelling approach. Multinomial logistic regression provided odds ratios (OR) and 95% confidence intervals (CI) for the associations between independent variables and sleep duration trajectory groups.

Results: A total of 3824 participants were included in the analyses. Three trajectories of sleep duration were identified: "short sleepers" (9.1%), "typical sleepers" (72.1%), and "initially longer sleepers" (18.8%). When compared to typical sleepers, children from less schooled mothers (OR 1.82, 95% CI 1.26, 2.62) and those whose mothers reported depressive symptoms during pregnancy (OR 1.31, 95% CI 1.02, 1.68) and consumed alcohol beverages at 3 months post-partum (OR 1.60, 95% CI 1.03, 2.50) were more likely to be short sleepers. Children who shared the bedroom with another child were about 40% (OR 1.41, 95% CI 1.07, 1.87) more likely to be short sleepers. None of the investigated maternal and child characteristics remained associated with the "initially longer sleeper" group.

Conclusions: Among the identified trajectories, the group with short sleep duration trajectory deserves special attention given the importance of adequate sleep duration in the first years of life for the child's growth and development and the high concomitance of other risk factors, such as less schooled mothers, and mothers who reported depressive symptoms during pregnancy and consumed alcohol at 3 months post-partum.

KEYWORDS

child, cohort studies, infant, sleep

1 | BACKGROUND

Sleep is a reversible behavioural state that plays a role in the reparative processes of the organism and has many functions. In childhood, the development of sleep occurs in parallel with cognitive development and physical growth.[1,2] Therefore, adequate sleep quantity and quality are fundamental for health, growth, and development in the first years of life.[1,2]

Short sleep duration is related to adverse outcomes in children, including health problems,[3,4] emotional and behavioural disorders,[5] and impaired cognitive development.[6,7] Although individual variability must be taken into account, the amount of sleep in a 24-hour period recommended by the *National Sleep Foundation* is around 14-17 hours for newborns, 12-15 hours for infants, 11-14 hours for toddlers, and 10-13 hours for pre-school children.[8] Despite its importance, sleep duration seems to be decreasing over time among children and adolescents.[9]

Sleep duration is determined by an interaction between genetic,[10] environmental, and sociocultural factors.[4,11] Although sleep duration has been studied in different populations of children, most of these studies were cross-sectional.[12,13] The importance of examining sleep duration in a longitudinal perspective relies especially on the possibility of identifying different patterns, such as chronic conditions of short sleep duration and related factors, in order to improve preventive interventions.

Few studies have used approaches to identify groups of individuals following different trajectories of sleep duration in childhood.[14,15] Therefore, this study aimed to identify the longitudinal trajectories of sleep duration between 3 and 48 months of age among children from the Pelotas (Brazil) 2004 Birth Cohort Study and associated maternal and child characteristics.

Synopsis

Study question

What are the sleep duration trajectories from 3 to 48 months of age and the associated maternal and child characteristics?

What's already known

Sleep duration is determined by an interaction between genetic, environmental, and sociocultural factors. Long-term sleep deprivation can be harmful to health.

What this study adds

Three different sleep duration trajectories were identified. One in each ten children fell into the short sleeper trajectory. Lower maternal schooling, depressive symptoms during pregnancy, maternal alcohol use at 3 months after birth, and sharing the bedroom with another child increased the odds of becoming short sleeper. The study fills gaps on longitudinal assessment of child sleep and related sociocultural factors from low- and middle-income countries.

2 | METHODS

2.1 | Participants

In the year 2004, a birth cohort study attempted to enrol all hospital livebirths that occurred between 1 January and 31 December in Pelotas, a medium-sized city in Southern Brazil with a population of ~342 405 inhabitants and a per capita gross domestic product 26% lower than the national mean.[16,17] A total of 4231 livebirths were enrolled in the cohort (non-response rate at recruitment was 0.75%). Mothers were interviewed after delivery (perinatal study) providing information on demographic, socio-economic, behavioural, and other characteristics. Household interviews were carried out at ages 3, 12, 24, and 48 months, when information on maternal and child health and behaviours was collected. A detailed description of the cohort can be found elsewhere.[18]

2.2 | Outcome

In each follow-up, mothers were asked to report on children's sleep in the previous 2 weeks. First, mothers were asked for the bed and wake time ("In the last two weeks, what time did the child go to bed?" and "what time did the child wake up?"). Mothers were also asked about how long it took the child to fall asleep (sleep latency). The answers were used to calculate nighttime sleep duration. Day naps were assessed by asking mothers: "In the last two weeks, on average how many times did the child sleep during the day?" and "How long, on average did the child sleep each time?" The answers were used to calculate daytime sleep duration. Next, mothers were asked whether "In the last two weeks the child woke up during the night?" "How many nights in the last two weeks?" and "How often per night?" These questions were used to calculate nighttime awakenings. Median duration of each awakening in the 3-, 12-, and 24-month follow-ups was estimated based on data from the control group of a sleep trial nested within The 2015 Pelotas Birth Cohort Study.[19] In this trial, 24-hour sleep duration was evaluated by objective measurement (actigraphy). At 3 and 12 months of age, each night awakening lasted 22 minutes, and at 24 months, was 7 minutes long (unpublished data). We also assigned 7 minutes to each night awakening at 48 months of age. In each follow-up, the number of nighttime awakenings and the estimated duration of each nocturnal awakening were used to estimate awaken time after sleep onset.

Sleep duration over the 24-hour period (total sleep duration) was calculated by adding the nighttime (subtracting sleep latency and awaken time after sleep onset) and daytime sleep duration. Possible outliers (according to the normal distribution of data) were analysed by two specialized analysts. Sleep duration greater than 21 hours at 3 months, fewer than 4 hours or longer than 20 hours at 12 months, and fewer than 4 hours or longer than 17 hours at 48 months was considered unlikely. Children with unlikely sleep duration were excluded from each corresponding follow-up (Figure 1).

Sleep duration measures at the 3-month follow-up were collected only in a subsample (mothers whose infants were born between 1 October and 31 December 2004). This subsample did not differ from the larger sample in any of the perinatal characteristics.

2.3 | Exposures

This study used the following variables from the perinatal study and the 3-month follow-up (prior and contemporaneous to the inception of sleep duration trajectories): socio-economic characteristics included family income in the month before the delivery, in Brazilian Real (categorized into tertiles). Maternal variables collected at the perinatal study included schooling (complete years of formal education, categorized as 0-4; 5-8; and ≥9); age (categorized as <20; 20-34; and ≥35 years); ethnicity (self-reported and categorized as white or black/mixed); marital status (widowed, divorced, or those living without a partner were considered single mothers); parity (number of previous live or stillbirths, categorized as <2 and ≥2); type of delivery (vaginal or caesarean section); depression during pregnancy (if answered positively to the question: "During pregnancy, did you feel depressed or have any nervous symptoms?"); number of antenatal care appointments (categorized as <6 and ≥6); heavy caffeine consumption during pregnancy (≥300 mg/d); smoking (at least one cigarette daily in any trimester of pregnancy); and prenatal alcohol consumption (any amount of alcohol intake during pregnancy). In the 3-month follow-up, mothers were asked about current smoking and alcohol consumption, and questioned whether they were already back to work. Child characteristics included sex, birthweight (measured by hospital staff with 10-g precision paediatric scales, low birthweight defined as <2500 g), preterm birth (<37 weeks), 5-min Apgar score <7 (yes/no), and intermediate or intensive neonatal care unit hospitalization after birth. In the 3-month follow-up, information about breast-feeding pattern, child hospitalizations after hospital discharge at birth, and room- and bed-sharing was collected from the mothers. Breastfed infants who did not receive any other fluids or solids (not even water or tea) were classified as in exclusive breast feeding.[20] Mothers were asked whether the child slept alone in a bedroom and, if not, how many children the bedroom was shared with. It was also asked whether the child slept in the same bed as the mother.

2.4 | Statistical analysis

The following eligibility criteria were considered to inclusion in the analyses: singleton children, to be alive until 48 months of age and have sleep duration data in at least two follow-ups.

Distinct sleep duration trajectories from 3 to 48 months of age were assessed by a semi-parametric, group-based modelling approach which identifies groups of individuals following similar developmental trajectories.[21,22] This is a specialized form of finite mixture modelling using a polynomial function to model the relationship between a characteristic, such as sleep duration, and age or time.[21-23] The models were estimated with the Stata procedure "traj."[24]

The number and shape of trajectories were based both on the best fit of the model (maximum Bayesian information criteria—BIC) and on the interpretability of the obtained trajectories. The selection of these trajectories was confirmed using the posterior probability score, which assesses the subject's probability of belonging to each trajectory group. This probability should be higher than 0.70 for all groups.[21]

The analyses were performed to verify associations between exposures and sleep duration trajectory groups. The measures of effect were estimated by multinomial logistic regression, providing odds ratios (ORs) and 95% confidence intervals (CIs). Typical sleepers were set as the reference group. Interaction tests were performed. The adjusted analysis considered three hierarchical levels according to a conceptual framework (Figure S1) constructed by the authors based on the previous literature. At the first level, family income and maternal sociodemographic (schooling, marital status, age, and ethnicity) and antenatal variables (parity, smoking, depression, alcohol and caffeine use during pregnancy, and number of antenatal care appointments) were included. At the second level, type of delivery and child perinatal variables were added (sex, birthweight, gestational age at birth, Apgar at 5 minutes, and intermediate or intensive care unit hospitalization after birth). The third level comprised maternal and child characteristics at the 3-month follow-up (maternal smoking and alcohol use, mother returned to work, exclusive breast feeding, child hospitalization, child room-sharing with another child, and bed-sharing with the mother). A backward strategy selection was used and the variable remained in the final model if the significance level was below 0.20 in at least one of both outcome categories. All analyses were performed with Stata software version 13.0 (StataCorp LP).

2.5 | Missing data

The group-based trajectory modelling handles missing data by using maximum likelihood estimation.[21]

2.6 | Sensitivity analyses

To account for differences in baseline characteristics between participants and nonparticipants and minimize the possibility of selection bias, we used propensity scores (PS) to calculate the inverse probability weights (IPW)[25] and perform weighted analysis. The PS were fit using logistic regression. IPW were calculated based on estimated PS and the balance assessed by standardized differences (Table S1).

Additionally, as a subsample of the cohort was assessed regarding sleep duration in the 3-month follow-up, a sensitivity analysis of sleep duration trajectories was performed including only children who had sleep duration information in all follow-ups.

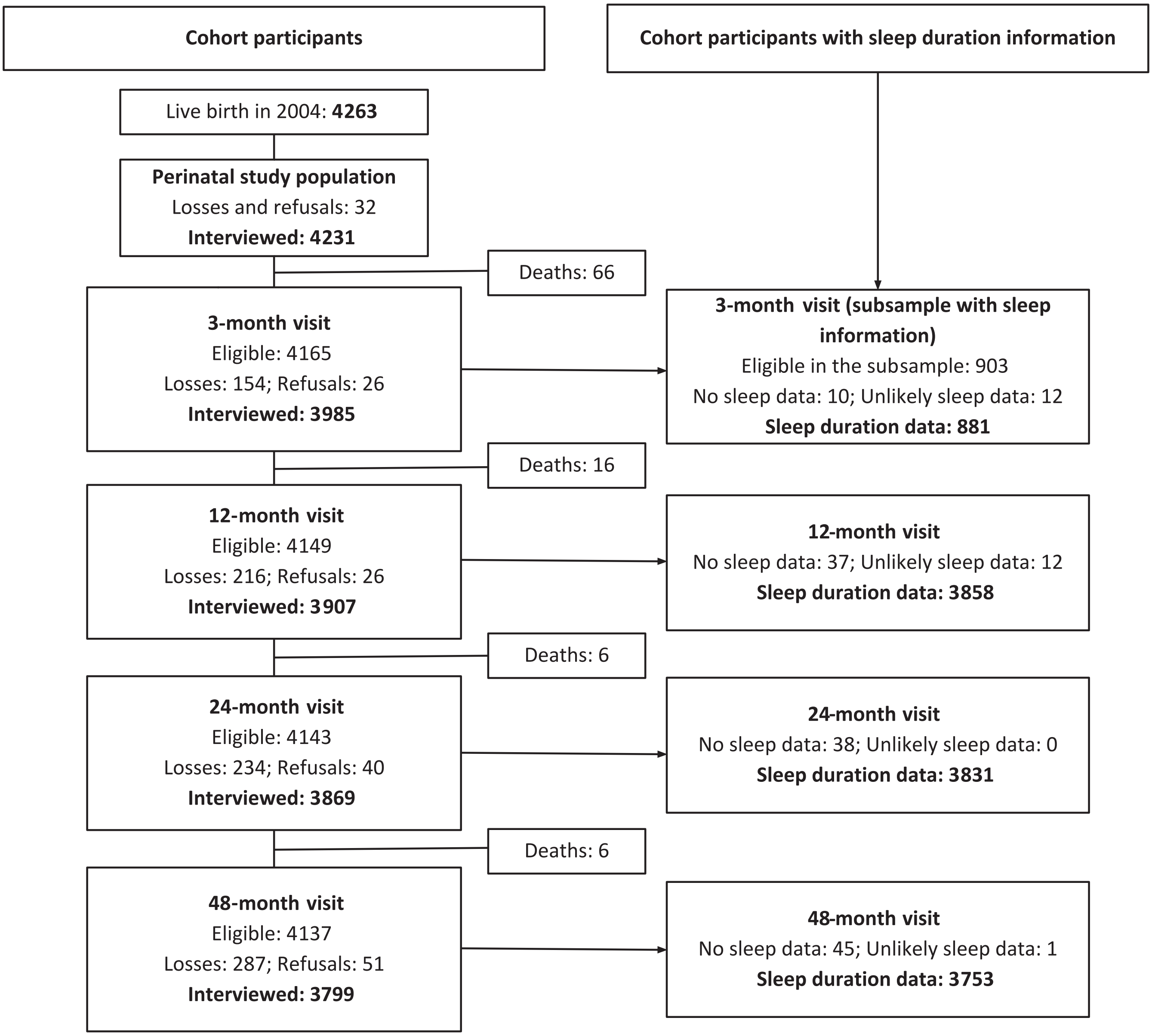

FIGURE 1 Participants' flow chart

2.7 | Ethics approval

This cohort complies with ethical standards and principles of the Declaration of Helsinki and was approved by the Medical Ethics Committee of the Federal University of Pelotas. Mothers provided a written informed consent in eachfollow-up.

3 | RESULTS

3.1 | Attrition analysis

Figure 1 shows the number of children with sleep duration information in each follow-up. After excluding 84 twins and 90 deaths (the total number of deaths up to 48 months was 94, four of them were among twins), 4057 from the 4231 participants constituting the original cohort were eligible for the analyses. A total of 233 children presented missing sleep duration data in more than two follow-ups, thus remaining 3824 children (94.3% of the eligible sample) to the trajectory analysis. The proportion of children belonging to the lowest family income tertile was higher among those not included in the analyses (Table 1).

3.2 | Identification of trajectories

The children mean (SD) ages at the four follow-ups were 3.1 (0.2), 11.9 (0.2), 23.9 (0.6), and 50.3 (1.8) months. The first step was to model trajectories of children's sleep duration specifying three-, four-, five-, and six-group models. Moving from the three-group to the four-group did not improve modelling (BIC values were similar). Moreover, in this case the average probability score turned smaller than 0.70 for some

TABLE 1 Comparison between children included and not included in the present study, according to maternal and child characteristics. Pelotas, Brazil, (n = 4057)[a]

Variables	Included (n = 3824) % (95% CI)	Not included (n = 233)[b] % (95% CI)
Family income (tertiles)		
1 (poorest)	32.8 (31.3, 34.3)	43.5 (37.2, 50.0)
2	34.0 (32.5, 35.5)	22.9 (17.9, 28.7)
3 (wealthiest)	33.2 (31.9, 34.8)	33.6 (27.8, 40.0)
Maternal schooling (y)[c]		
0-4	15.2 (14.1, 16.4)	17.0 (12.6, 22.4)
5-8	46.4 (44.8, 48.0)	46.5 (40.1, 53.0)
≥9	38.4 (36.8, 39.9)	36.5 (30.5, 43.0)
Maternal age (y)		
<20	18.9 (17.7, 20.2)	19.4 (14.8, 25.0)
20-34	70.5 (69.0, 71.9)	72.4 (66.3, 77.8)
≥35	10.6 (9.7, 11.6)	8.2 (5.3, 12.5)
Maternal race (white) (%)	73.2 (71.7, 74.6)	76.7 (70.8, 81.8)
Single mother (%)	15.9 (14.8, 17.1)	16.8 (12.5, 22.2)
Parity ≥ 2 (%)	60.3 (58.7, 61.8)	60.3 (53.9, 66.5)
Depression or nervous symptoms during pregnancy (%)	24.6 (23.3, 26.0)	28.0 (22.6, 34.2)
Smoking during pregnancy (%)	27.3 (25.9, 28.7)	27.2 (21.8, 33.3)
Alcohol consumption during pregnancy (%)	3.3 (2.8, 3.9)	2.6 (1.2, 5.7)
Caesarean (%)	44.7 (43.1, 46.2)	45.7 (39.3, 52.2)
Child sex (male) (%)	51.9 (50.3, 53.5)	50.6 (44.2, 57.1)
Low birthweight (%)	8.0 (7.1, 8.9)	9.1 (6.0, 13.5)
Preterm birth (%)	12.8 (11.7, 13.8)	13.4 (9.6, 18.5)
Intermediate or neonatal intensive care unit hospitalization after birth (%)	8.2 (7.4, 9.1)	8.2 (5.3, 12.6)

[a]84 twins and 90 deaths were excluded from the original cohort.
[b]233 children with missing data in more than 2 follow-ups.
[c]variable with the highest number of missing data (n = 39 missing data).

groups, indicating low probability of the individual belonging to each of the trajectory groups. Therefore, based on model parameters and interpretability of the obtained trajectories, the three-group model emerged as the best fitting and most parsimonious model.

The three trajectories were best represented by a cubic term. For all three groups, the posterior probability was above the recommended threshold for assignment of 0.70 (average posterior probability of 0.76, 0.78, and 0.77 for Group 1 to Group 3, respectively) (Table S2). Group 1 (named "short sleepers," n = 348) comprised 9.1% of the children, group 2 ("typical sleepers," n = 2757) represented 72.1% of the whole cohort, and the group 3 ("initially longer sleepers," n = 719) was composed by 18.8% of the children (Figure 2).

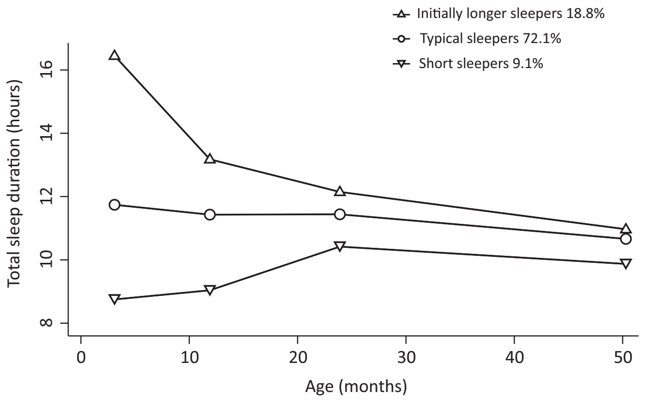

FIGURE 2 Trajectories of sleep duration according to the age of the child. The 2004 Pelotas Birth Cohort, Brazil (n = 3824)

3.3 | Associated factors to children's sleep duration trajectories

Children from the poorest families, born to non-white ethnicity mothers, with lower schooling level, depression or nervous symptoms during pregnancy, and who smoked at 3-month post-partum, as well as those who shared the bedroom with another child, were more likely to be short sleepers, compared to the others (Table 2).

Interaction tests performed with the variables most strongly associated with the outcome showed no effect modifications: for the short sleepers group, family income *vs.* maternal education (*P*-value = .067), family income *vs.* room-sharing (*P*-value = .102), and maternal education *vs.* room-sharing (*P*-value = .928); for the initially longer sleepers group, family income *vs.* exclusive breast feeding (*P*-value = .682).

Unadjusted OR for sleep duration trajectory groups showed that compared to typical sleepers, children from the lowest tertile of family income in relation to the highest one, those whose mothers were less schooled, had depression or nervous symptoms, and smoked during pregnancy were more likely to be short sleepers (Table 3). White mothers and those who attended at least 6 antenatal appointments were less likely to have babies in the short sleeping group. Children whose mothers smoked and used alcohol at 3-month post-partum and those who shared the bedroom with another child had higher odds of being short sleepers. Children belonging to the intermediate family income group and whose mothers were <20 years old were more likely to be initially longer sleepers, while those exclusively breastfed at 3 months were less likely to belong to this group (Table 3).

After adjustment, children whose mothers had 0-4 and 5-8 years of schooling had, respectively, 82% (95% CI 1.26, 2.62) and 37% (95% CI 1.03, 1.82) greater odds of being short sleepers, compared to those from mothers with ≥9 years of schooling (Table 4). Maternal depression or nervous symptoms during pregnancy and alcohol consumption at 3 months increased the odds of belonging to the short sleeper group by approximately 30% (95% CI 1.02, 1.68) and 60% (95% CI 1.03, 2.50), respectively. Children who shared the bedroom with another child had 40% (95% CI 1.07, 1.87) greater odds of being short sleepers (Table 4).

TABLE 2 Description of sleep duration trajectory groups in terms of maternal and child characteristics. Pelotas, Brazil (n = 3824)

	Sleep duration trajectories		
Variables	Short sleepers N = 348 % (95% CI)	Typical sleepers N = 2757 % (95% CI)	Initially longer sleepers N = 719 % (95% CI)
Sociodemographic characteristics			
Family income (tertiles)			
1 (poorest)	40.2 (35.2, 45.5)	32.0 (30.3, 33.8)	32.3 (28.9, 35.8)
2	33.3 (28.6, 38.5)	33.2 (31.5, 35.0)	37.1 (33.7, 40.7)
3 (wealthiest)	26.5 (22.0, 31.3)	34.8 (33.0, 36.6)	30.6 (27.3, 34.1)
Maternal schooling (y)			
0-4	22.1 (18.0, 26.8)	14.4 (13.1, 15.8)	15.2 (12.7, 18.0)
5-8	49.4 (44.1, 54.7)	45.4 (43.6, 47.3)	48.6 (44.9, 52.3)
≥9	28.5 (23.9, 33.5)	40.2 (38.4, 42.0)	36.2 (32.8, 39.8)
Maternal age (y)			
<20	18.7 (14.9, 23.1)	18.1 (16.8, 19.6)	22.0 (19.1, 25.2)
20-34	68.4 (63.3, 73.1)	71.3 (69.6, 73.0)	68.1 (64.6, 71.5)
≥35	12.9 (9.8, 16.9)	10.6 (9.4, 11.7)	9.9 (7.9, 12.3)
Maternal race (white)	67.2 (62.1, 72.0)	74.2 (72.6, 75.8)	71.9 (68.5, 75.1)
Single mother	17.0 (13.4, 21.3)	15.6 (14.3, 17.0)	16.7 (14.1, 19.6)
Antenatal characteristics			
Parity ≥ 2	64.7 (59.5, 69.5)	60.5 (58.6, 62.3)	57.4 (53.8, 61.0)
Depression or nervous symptoms during pregnancy	31.3 (26.6, 36.4)	23.9 (22.3, 25.5)	24.2 (21.2, 27.5)
Smoking during pregnancy	32.2 (27.5, 37.3)	27.0 (25.4, 28.7)	25.9 (22.8, 29.2)
Alcohol use during pregnancy	4.6 (2.8, 7.4)	3.0 (2.5, 3.8)	3.6 (2.5, 5.3)
Caffeine consumption during pregnancy (≥300 mg/d)	18.7 (15.0, 23.2)	15.6 (14.3, 17.0)	17.6 (15.0, 20.6)
Number of antenatal care appointments (at least 6)[a]	78.0 (72.9, 82.0)	82.5 (81.0, 83.9)	83.2 (80.2, 85.8)
Perinatal characteristics			
Caesarean	45.1 (39.9, 50.4)	44.8 (42.9, 46.6)	44.1 (40.5, 47.8)
Male sex	53.4 (48.2, 58.7)	51.9 (50.1, 53.8)	50.9 (47.2, 54.6)
Low birthweight	10.1 (7.3, 13.7)	7.4 (6.5, 8.4)	9.1 (7.2, 11.4)
Preterm birth	14.9 (11.6, 19.1)	12.6 (11.4, 13.9)	12.3 (10.1, 14.9)
Apgar 5° minute < 7	1.4 (0.6, 3.4)	1.4 (1.0, 1.9)	2.0 (1.2, 3.3)
Intermediate or intensive care unit hospitalization after birth	7.5 (5.1, 10.8)	7.9 (7.0, 9.1)	9.2 (7.3, 11.6)
Maternal characteristics at 3 m			
Maternal smoking	33.3 (28.5, 38.5)	25.7 (24.1, 27.4)	23.5 (20.5, 26.8)
Maternal alcohol use	7.6 (5.2, 11.0)	4.9 (4.1, 5.8)	4.4 (3.1, 6.1)
Mother returned to work	15.5 (12.1, 19.8)	13.1 (11.9, 14.5)	15.2 (12.7, 18.0)
Child characteristics at 3 m			
Exclusive breast feeding	28.7 (24.2, 33.7)	28.4 (26.8, 30.2)	23.5 (20.5, 26.8)
Hospitalization up to 3 m	8.2 (5.7, 11.6)	6.4 (5.5, 7.3)	6.9 (5.2, 9.0)
Room-sharing with another child	42.4 (37.2, 47.7)	31.3 (29.6, 33.1)	29.8 (26.6, 33.3)
Bed-sharing with the mother	51.2 (45.9, 56.5)	46.0 (44.1, 47.9)	45.9 (42.2, 49.5)

[a]Variable with the highest number of missing data (n = 156 missing data).

3.4 | Sensitivity analyses

The weighted analyses using IPW are presented in Table S3 and Table S4. There were no differences in comparison with unweighted study results.

A total of 766 children had sleep duration information in all follow-ups. In this subsample, the same number of trajectories was identified (Figure S2), and the shapes were similar, even though the percentage of typical sleepers was lower compared to the whole sample.

4 | COMMENT

4.1 | Principal findings

This study identified three groups of sleep duration trajectory in early childhood. While short sleepers presented a worse profile regarding some maternal and child characteristics, initially longer sleepers seemed to be a more heterogeneous group. Considering the current recommendation from the *National Sleep Foundation*,[8] children belonging to the short sleepers group slept less than recommended in all periods. Initially, longer sleepers were within the threshold recommendations in all ages, whereas at 3 months, they slept on average 5 hours longer than the typical sleepers. Maternal characteristics (lower schooling, depression or nervous symptoms during pregnancy, and alcohol use at 3-month post-partum) and room-sharing with another child increased the odds of belonging to the short sleeper group.

4.2 | Strengths of the study

Sleep trajectories were determined by establishing longitudinal sleep duration patterns, which reflects a chronic condition and allows a different and more robust observation, when compared with specific observations over time. This large, population-based sample with high social diversity and high follow-up rates allowed us to investigate the characteristics associated with each sleep pattern. In addition, there were no changes in study results when the weighted analyses were performed and similar sleep trajectories were obtained when only children with sleep duration information in all follow-ups were analysed. Finally, as reported in another study,[11] there are cultural and regional differences in some of the sleep duration-associated characteristics, thus reinforcing the importance of studying sleep patterns in different settings.

4.3 | Limitations of the data

As objective methods could provide more accurate data, the maternal report as a measure to evaluate child sleep duration is a limitation of this study. Parent reporting may overestimate sleep duration and variables such as naps and nighttime awakenings may be biased.[26] However, this subjective methodology has been widely used in population-based research.[12,13] Another limitation is that night awakening duration was not directly obtained from the sample; however, this duration was estimated from a sample recruited at the same setting. If night awakening duration estimation was not suitable to our sample, it would have led to a non-differential misclassification error of the outcome. In most situations, non-differential misclassification produces bias towards the null, thus the lack of association with some of the independent variables may be due to this misclassification error.

4.4 | Interpretation

The differences in sleep duration between trajectories were higher in the first follow-ups and became less pronounced as the age of the child increased. Such finding was also described among 2926 Australian children followed from age 0-1 to 6-7 years.[14] As the development and consolidation of sleep occur, inter-individual variability tends to decrease over time.[1]

In the Australian study cited above,[14] sleep duration evaluated by maternal report identified four groups of children: "typical sleepers" (40.6%), "initially short sleepers" (45.2%), "poor sleepers" (2.5%), and "persistent short sleepers" (11.6%). The "poor sleepers" and "persistent short sleepers" groups were similar to our "short sleepers" group. As in our study, children from those groups also belonged to families from lower socio-economic status and presented other social disadvantages.[14]

Our "short sleepers" presented a lower mean of sleep duration in comparison with the Australian "poor sleepers" and "persistent short sleepers" between 0 and 1 year of age.[14] A study comparing sleep duration in children from different countries highlighted differences between predominantly Asian and predominantly Caucasian countries.[11] Children from predominantly Asian countries presented shorter total sleep times than children from predominantly Caucasian countries/regions.[11] Although no Latin American countries were included, these findings suggest that our results may be at least in part due to regional differences in sleeping patterns.

Insufficient sleep has negative impacts. The infant sleep architecture is different from that of adults, with a greater predominance of REM (rapid eye movement) sleep, also called "paradoxical sleep" due to intense brain activity concomitantly with the full relaxation of muscle tone.[2] Infants need more of this type of sleep compared to NREM (non-rapid eye movement) as it is related to information processing and memory establishment, and it is, therefore, fundamental to central nervous system maturation.[1,2] In addition to learning impairments which could be related to insufficient sleep,[6] chronic sleep deprivation throughout life has been associated with worsening of the immune system, increased inflammatory mediators, and altered glucose metabolism and other hormonal changes.[3]

Corroborating with some of the findings of this study, a British cohort study of 1702 children found that shorter sleep duration was associated with lower maternal schooling, non-white ethnicity, male gender, low birthweight, and living with an older child at home.[27] The association with lower maternal education may be related to the lack of information and knowledge about sleep in childhood.

Another cohort study with Canadian children found that lower maternal schooling and prenatal depression were associated with shorter sleep duration,[28] with maternal depression mediating the association between low maternal schooling and the child's short sleep duration.[28] Prenatal anxiety and depression were also associated with more sleep

TABLE 3 Unadjusted analysis for sleep duration trajectory groups (typical sleepers as reference), according to maternal and child characteristics. Pelotas, Brazil

Variables	Sleep duration trajectories	
	Short sleepers OR (95% CI)	Initially longer sleepers OR (95% CI)
Sociodemographic characteristics		
Family income (tertiles)		
1 (poorest)	1.65 (1.25, 2.19)	1.15 (0.93, 1.41)
2	1.32 (0.99, 1.76)	1.27 (1.04, 1.55)
3 (wealthiest)	1.00 (Reference)	1.00 (Reference)
Maternal education (years)		
0-4	2.17 (1.57, 3.00)	1.17 (0.91, 1.51)
5-8	1.53 (1.18, 2.00)	1.19 (0.99, 1.42)
≥9	1.00 (Reference)	1.00 (Reference)
Maternal age (years)		
<20	1.07 (0.80, 1.44)	1.27 (1.03, 1.55)
20-34	1.00 (Reference)	1.00 (Reference)
≥35	1.28 (0.91, 1.80)	0.98 (0.74, 1.30)
Maternal race (white)	0.71 (0.56, 0.90)	0.89 (0.74, 1.07)
Single mother	1.10 (0.82, 1.49)	1.08 (0.87, 1.35)
Antenatal characteristics		
Parity ≥ 2	1.20 (0.95, 1.51)	0.88 (0.75, 1.04)
Depression or nervous symptoms during pregnancy	1.45 (1.14, 1.85)	1.02 (0.84, 1.23)
Smoking during pregnancy	1.28 (1.01, 1.63)	0.94 (0.78, 1.14)
Alcohol during pregnancy	1.53 (0.89, 2.65)	1.19 (0.76, 1.87)
Caffeine consumption during pregnancy (≥300 mg/d)	1.25 (0.94, 1.67)	1.16 (0.93, 1.44)
Number of antenatal care appointments (at least 6)	0.74 (0.56, 0.98)	1.05 (0.84, 1.31)
Perinatal characteristics		
Caesarean	1.01 (0.81, 1.27)	0.97 (0.82, 1.15)
Male sex	1.06 (0.85, 1.33)	0.96 (0.81, 1.13)
Low birthweight	1.40 (0.96, 2.04)	1.25 (0.93, 1.67)
Preterm birth	1.22 (0.89, 1.67)	0.97 (0.76, 1.25)
Apgar 5° minute < 7	1.04 (0.41, 2.67)	1.43 (0.77, 2.65)
Intermediate/intensive care unit hospitalization after birth	0.93 (0.61, 1.42)	1.17 (0.87, 1.56)
Maternal characteristics at 3 months		
Maternal smoking	1.45 (1.14, 1.84)	0.89 (0.73, 1.08)
Maternal alcohol use	1.60 (1.04, 2.48)	0.89 (0.60, 1.33)
Mother returned to work	1.22 (0.89, 1.67)	1.18 (0.94, 1.50)
Child characteristics at 3 months		
Exclusive breast feeding	1.01 (0.79, 1.30)	0.77 (0.64, 0.94)
Hospitalization up to 3 months	1.31 (0.87, 1.99)	1.09 (0.78, 1.51)
Room-sharing with another child	1.61 (1.28, 2.03)	0.93 (0.78, 1.12)
Bed-sharing with the mother	1.23 (0.98, 1.54)	0.99 (0.84, 1.17)

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.

problems at 18 and 30 months in a British cohort.[29] The plausibility of these relationships may be due to different mechanisms, and increases in cortisol may be one of them[30] which may also alter sleep architecture.[31]

In this study, maternal alcohol consumption at 3 months post-partum was associated with higher odds of becoming short sleeper. Alcohol appears to cause circadian rhythm disruption. Gestational alcohol exposure affects foetal sleep-wake states, causing sleep

TABLE 4 Final adjusted model for sleep duration trajectory groups (typical sleepers as reference), according to maternal and child characteristics. Pelotas, Brazil

	Sleep duration trajectories	
Variables	Short sleepers OR (95% CI)	Initially longer sleepers OR (95% CI)
Sociodemographic characteristics		
Family income (tertiles)		
1 (poorest)	1.19 (0.87, 1.64)	1.06 (0.84, 1.34)
2	1.06 (0.78, 1.45)	1.22 (0.99, 1.51)
3 (wealthiest)	1.00 (Reference)	1.00 (Reference)
Maternal education (y)		
0-4	1.82 (1.26, 2.62)	1.17 (0.88, 1.55)
5-8	1.37 (1.03, 1.82)	1.15 (0.95, 1.41)
≥9	1.00 (Reference)	1.00 (Reference)
Maternal race (white)	0.83 (0.64, 1.06)	0.91 (0.75, 1.10)
Antenatal characteristics		
Parity ≥ 2	1.04 (0.82, 1.33)	0.85 (0.71, 1.00)
Depression or nervous symptoms during pregnancy	1.31 (1.02, 1.68)	1.00 (0.82, 1.21)
Perinatal characteristics		
Low birthweight	1.30 (0.85, 2.00)	1.34 (0.96, 1.86)
Preterm birth	1.02 (0.72, 1.46)	0.82 (0.62, 1.09)
Maternal characteristics at 3 m		
Maternal smoking	1.19 (0.92, 1.54)	0.83 (0.68, 1.02)
Maternal alcohol use	1.60 (1.03, 2.50)	0.90 (0.60, 1.35)
Mother went back to work	1.25 (0.91, 1.72)	1.24 (0.98, 1.57)
Child characteristics at 3 m		
Exclusive breast feeding	1.25 (0.96, 1.62)	0.83 (0.68, 1.00)
Room-sharing with another child	1.41 (1.07, 1.87)	0.93 (0.75, 1.16)

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval

fragmentation and decrease in REM sleep and, in childhood, is associated with shorter sleep duration and poor sleep efficiency.[32] A reduction in REM sleep has also been observed in children whose mothers ingested alcohol before breast feeding, indicating that short-term exposure to small amounts of alcohol in mothers' milk may produce changes in the infants' sleep-wake patterning.[33]

Children who shared the room with another child were more likely to be short sleepers, which could be due to negative effects on sleep hygiene, like increased noise in the environment. Room-sharing, especially with parents/caregivers, seems to be a culturally determined behaviour.[11,34,35] In a study with Chinese children, room-sharing was associated with sleep problems, including shorter duration, compared to sleeping alone in a different room.[36]

The direction of an observed association needs to be highlighted: Children who were exclusively breastfed at 3 months were less likely to become initially longer sleepers. Breastfed children have more fragmented sleep due to breast-feeding frequency. Recently, the early food introduction (before 4 months) was reported as increasing the duration of sleep and reducing the number of nocturnal awakenings.[37] However, the proven benefits of exclusive breast feeding up to 6 months for the child's health[38] may surpass the potential advantages of a longer sleep.

5 | CONCLUSIONS

Our results have provided a new overview of sleep during childhood by highlighting sleep duration trajectories of children from a medium-sized city in Brazil, bridging a data gap in the literature from low- and middle-income countries. One in each ten children was a short sleeper throughout the early childhood. Given the fundamental importance of adequate sleep duration in the first years of life and considering that short sleepers were also exposed to other risk factors, such as less schooled mothers, and mothers who reported depressive symptoms during pregnancy and consumed alcohol at 3 months post-partum, this group deserves special attention.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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