AUTHOR(S)
Aukia, L., Paavonen, E. J., Karlsson, L., Pelto, J., Perasto, L., Karlsson, H., & Polo-Kantola, P.

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Linda Aukia[1] (ORCID-ID 0000-0003-1930-2984), E. Juulia Paavonen[2, 3] (ORCID-ID 0000-0002-1421-9877), Linnea Karlsson[4, 5, 6] (ORCID-ID 0000-0002-4725-0176), Juho Pelto[4,7] (ORCID-ID 0000-0001-8820-8014), Laura Perasto[4,8] (ORCID-ID 0009-0003-3209-0506), Hasse Karlsson [4, 6, 9](ORCID-ID 0000-0002-4992-1893), Päivi Polo-Kantola[1] (ORCID ID 0000-0003-0665-0306)

1 Department of Obstetrics and Gynecology, Turku University Hospital and University of Turku, Turku, Finland
2 Pediatric Research Center, Child Psychiatry, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
3 Department of Public Health and Welfare, Finnish institute for Health and Welfare
4 FinnBrain Birth Cohort Study, Turku Brain and Mind Center, Department of Clinical Medicine, University of Turku, Turku, Finland
5 Department of Pediatrics and Adolescent Medicine, Turku University Hospital and University of Turku, Turku, Finland
6 Centre for Population Health Research, Turku University Hospital and University of Turku, Turku, Finland
7 University of Turku, Department of Mathematics and Statistics, Turku, Finland
8 Centre for Population Health Research, University of Turku and Turku University Hospital, Turku, Finland
9 Department of Psychiatry, Turku University Hospital and University of Turku, Turku, Finland

Correspondence:
Linda Aukia
Department of Obstetrics and Gynecology, Turku University Hospital and University of Turku, Turku, Finland
Savitehtaankatu 5, 20520 Turku, Finland
Email: linda.aukia@tyks.fi

Abstract

Purpose To investigate sleep duration and sleep loss during antenatal period and assess associative factors, including maternal characteristic and mood symptoms.

Methods A cohort of 3,038 women was enrolled. Self-reported sleep duration and sleep loss, the latter being calculated from preferred sleep need and actual sleep duration, were measured in early, mid- and late pregnancy, and at delivery. The associations with age, BMI, parity, education, smoking, napping, and depressive and anxiety symptoms were evaluated.

Results Sleep duration was longest in early pregnancy and shortest at delivery (7.93h to 7.76h, $p<0.001$). The proportion of short sleepers (<6 hours) increased from 1.4% to 5.9% throughout the studied period ($p<0.001$). Mean sleep loss remained stable in early- and mid-pregnancy, lowering in late pregnancy ($p<0.001$) and increasing again until delivery ($p=0.003$). The number of women with notable sleep loss (>2 hours) was similar during the first three measurement points (9.4%, 8.9% and 9.5%), but increased until delivery (14.1%, $p<0.001$). Older, multiparous, and more-depressive women slept less ($p<0.001$, $p<0.001$, $p=0.017$). Women with higher BMI were more likely to sleep <6 hours in late pregnancy ($p=0.012$). Multiparous, more-depressive, and higher-BMI women reported more sleep loss ($p<0.001$, $p<0.001$, $p=0.049$).

Conclusion We confirmed earlier reported decrease in sleep duration at the end of pregnancy. As a novel finding, we showed a notable increase in sleep loss during the last month of pregnancy. Various factors were associated with both short sleep and sleep loss, especially multiparity, napping and depressive symptoms.

Key words: Age, BMI, mother, mood symptoms, pregnant, sleep duration, sleep loss

What does this study add to the clinical work:

Sleep duration decreased and notable sleep loss increased during pregnancy, with various factors contributing to these changes. These findings should be considered by healthcare providers, as previous literature has indicated that inadequate sleep duration is associated with adverse pregnancy and delivery outcomes.

Introduction

Sleep quality impairment and sleep disturbances are common during pregnancy [1–4]. Nevertheless, up to now, previous literature of sleep during pregnancy is still limited. This may be due to general assumption that pregnancy-related sleep disturbances are ordinary and temporary in nature. However, sleep disturbances have shown to be associated with an increased risk for adverse pregnancy and delivery outcomes [5]. Furthermore, pregnancy related sleep disturbances may precede postpartum depression and become chronical [6, 7].

Previous studies have mainly proposed a decrease in sleep duration towards the end of the pregnancy [3, 8]. However, one study found an increase from pre-pregnancy to the first trimester and decrease thereafter [3], and another study a shorter sleep duration in the third trimester compared to pre-pregnancy [9]. Nevertheless, previous literature is partly based on cross-sectional data, while longitudinal studies with representative sample sizes and multiple measurement points are infrequent. Studying sleep duration during pregnancy is clinically relevant, as it has been associated with several pregnancy complications [5]. Both short and long sleep duration have been associated with gestational diabetes and pre-eclampsia [5, 10] and short sleep duration with preterm labor, longer duration of delivery, and increased risk for operative delivery [5, 11, 12].

Sleep loss implies lack of sleep, and it reflects the difference between self-reported sleep need and actual sleep duration. Because sleep need varies between individuals, sleep loss may a be more informative parameter than actual sleep duration when considering the adverse effects of inadequate sleep [13]. In one general-population study in which insufficient sleep was defined as a difference of at least 1h between sleep need and sleep duration, 24% of women reported to suffer from sleep loss [14]. A cross-sectional study among pregnant women from Finland reported that 7% of women in the third trimester suffered from a sleep loss of over 2h

[15]. However, no previous longitudinal studies of sleep loss during the pregnancy have been published.

Several characteristics may influence sleep during pregnancy. In previous research, age [16], parity [10], marital status [10], educational level [10], and employment [3] have been shown to be associated with sleep duration. Furthermore, mood symptoms are commonly related to sleep [6, 17, 18]. A few studies have shown that depression is related to short sleep duration during pregnancy both in early [19] and in late pregnancy [15], as well as throughout pregnancy [21].

We conducted a prospective follow-up study to assess changes in self-reported sleep duration and sleep loss during pregnancy. We also evaluated associative factors for these changes and sought to determine the associative factors for short (<6h) and long (>10h) sleep durations, as well as for extreme sleep loss (>2h). We hypothesized that sleep duration shortens, and sleep loss increases as pregnancy proceeds and that these findings are associated with maternal characteristics, especially with mental symptoms.

Material and Methods

Subjects

The present study was a part of a longitudinal FinnBrain Birth Cohort Study carried out at the University of Turku (www.finnbrain.fi) [22]. Pregnant women were recruited by research nurses in Turku and Åland hospital districts at the routine ultrasound appointment around gestational week (gwk) 12. The women received oral and written information, and a written consent was required to participate in the study. The cohort consisted of 3,808 women, of whom 3,038 returned the background information questionnaire and at least one sleep

questionnaire during pregnancy and were accepted to the study (Fig. 1). Forty percent of the women (n=1226) completed all four questionnaires on time.

Questionnaires

Sleep quality over the previous month was evaluated with the Basic Nordic Sleep Questionnaire (BNSQ) [23], of which three questions were used in this study: 1) sleep duration/night, 2) sleep need/night, and 3) napping during the day. Sleep loss was computed by subtracting sleep need from sleep duration (minutes). Napping during the day was rated on a 5-point scale: 1=’never or less than once a month’, 2=’less than once a week’, 3=’once or twice a week’, 4=’three to five times a week’, and 5=’daily or almost daily’. Questionnaires were assessed four times during pregnancy. The early, mid-, and late pregnancy questionnaires were sent via either post or email, and if no response was received within two weeks, a reminder was sent twice via text message 2 and 3 weeks after the original questionnaire. The delivery time point questionnaire was assessed in the maternity ward after delivery. In that questionnaire, the women also considered their sleep quality over the previous month, specifically during pregnancy before delivery. Majority filled in this fourth questionnaire within the third day postpartum, latest at the 7th day postpartum.

The Edinburgh Postnatal Depression Scale (EPDS) [24, 25] was used to measure depressive symptoms in early pregnancy, with the sum score ranging from 0–30, and a higher score indicating higher depressive symptoms. Anxiety was assessed using Symptom Checklist-90/Anxiety Scale (SCL-90/Anxiety Scale) [26, 27], with the sum score ranging from 0–40, and a higher score indicating higher anxiety symptoms. Depressive and anxiety symptoms and background information (marital status [married/cohabitating/divorced/single], education [low (at most a trade school or a high school level education)/mid (at most a university of applied sciences level education)/high (University level education (candidate/master)] and smoking

[no/yes]) were administered together with the early pregnancy time point sleep questionnaire. Other basic characteristics were drawn from the Finnish Medical Birth Register, including age (years), body mass index (BMI kg/m^2), and parity (nulliparous/multiparous [number of children]). The characteristics of the women and gestational weeks (gwks) for responses are described in Table 1.

Statistical analyses

Continuous variables were characterized using means, standard deviations (SD), and ranges, and categorical variables with frequencies and percent. Differences in mean sleep duration between the time points (early, mid-, and late pregnancy and delivery) were analyzed using a linear mixed model. Differences between the time points in the percentage of women sleeping <6 h/night and the percentages sleeping >10 h/night were analyzed using the function Prop.test in the R package Partially Overlapping. This function is designed to test differences in binary variables between partially overlapping samples.

Associations between different predictors (parity [nulliparous/multiparous], education [low/mid/high], smoking [no/yes], and napping [< 3 times/week/≥3 times/week] as categorical variables and age [years], BMI [kg/m^2], and EPDS and SCL scores as continuous variables) and continuous sleep duration throughout pregnancy were analyzed with the linear mixed model. The Main Model was first used to analyze whether each predictor explained any variation in sleep duration by comparing the Main Model to the Main Model without the predictor of interest via a likelihood ratio test. Further, associations between different predictors and sleeping <6 h/night at each time point were analyzed using logistic regression models. Similar analyses were performed between different predictors and sleeping >10

h/night. These results are presented using odds ratios (OR) with 95% confidence intervals (CIs).

The corresponding analyses for sleep loss (both continuous and categorical [sleep loss >2h/night]) were carried out in the same way. All analyses were performed in R 4.0.5. The mixed models were fitted using the package lme4, and the missing values in the predictors were imputed using missForest. *P*-values less than 0.05 were considered statistically significant.

Results

Sleep duration

Mean sleep duration in early pregnancy was 7.93h±1.01h (475.8min±60.6min), in mid-pregnancy 7.84h±0.98h (470.4min±58.8min), in late pregnancy 7.89h±1.16h (473.4min±69.6 min) and at delivery 7.76h±1.34h (465.6min±80.4 min). Sleep duration decreased from early to mid-pregnancy (5.4min, $p<0.001$), increased from mid to late pregnancy (3.0min, $p=0.001$) and decreased again being the shortest at delivery (7.8min, $p<0.001$; Fig. 2a). The other comparisons were as follows: early versus late 2.4min, $p=0.36$; early versus delivery 10.2min, $p<0.001$; mid versus delivery 3.0min, $p=0.28$.

Percentages of women sleeping <6 h/night were similar between early and mid-pregnancy (1.4% and 1.6%, $p=0.511$), but increased in late pregnancy (3.0%, both $p<0.001$) and even more at delivery (5.9%, all $p<0.001$). Percentages of women sleeping >10 h/night remained stable (0.6–1.0%) during the pregnancy (Fig. 3a).

According to linear mixed model analyses, when sleep duration was considered as continuous, younger women slept longer compared to older women (overall $p<0.001$; $p<0.001$ at all pregnancy points; Fig. 2b), and multiparous women slept less than nulliparous women (overall $p<0.001$; late pregnancy $p<0.001$, delivery $p=0.02$; Fig. 2d). Women who took naps ≥3 times/week slept less (overall $p<0.001$; mid-pregnancy $p<0.001$, late pregnancy $p<0.001$, delivery $p<0.001$; Fig. 2e) and women with more depressive symptoms also slept less (overall $p=0.017$; delivery $p=0.024$; Fig. 2f). There was no correlation between sleep duration and anxiety symptoms (overall $p=0.631$)

According to logistic regression analyses (Table 2), when sleep duration was considered as categorical using the cut-off point <6 h, older women were more likely to sleep <6 h/night in all pregnancy points. Women with higher BMI were more likely to sleep <6 h/night in late pregnancy. Those with high education were more likely to sleep <6 h/night in late pregnancy compared to women with low education. Smokers were more likely to sleep <6 h/night in early pregnancy and at delivery. Further, women who took naps ≥3 times/week were more likely to sleep <6 h/night in late pregnancy and at delivery, and women with more depressive symptoms were more likely to sleep <6 h/night in early pregnancy.

As for sleep duration >10 h (logistic regression analyses; Table 3), only sporadic associations emerged. Older women were less likely to sleep >10 h/night in mid-pregnancy, and women with mid-level education were less likely to sleep >10 h/night in early pregnancy and at delivery compared to women with low education.

Sleep loss

Mean sleep loss remained stable between early (mean 0.99h±1.09 h, 59.57min±65.1min) and mid-pregnancy (mean 1.01h±1.03h, 60.7min±61.6min, $P=0.051$). It decreased at late

pregnancy (mean 0.91h±1.14h, 54.8min±68.3min [early vs late, $p<0.001$; mid vs late $p<0.001$]) and increased again from late pregnancy to delivery ($p=0.003$), reaching the level of early- and mid-pregnancy (delivery mean 1.01h±1.30h, 60.4min±77.8min; Fig. 4a).

In early pregnancy, 33.2% of women reported sleep loss >1h/night, and the percentages in mid- and late pregnancy and at delivery were 34.3%, 29.1%, and 31.9%, respectively. Percentages of women reporting sleep loss >2 h/night remained stable throughout early (9.4%), mid- (8.9%), and late pregnancy (9.5%) (early vs mid $p=0.901$, early vs late $p=0.081$, mid vs late $p=0.899$), but increased at delivery (14.1%, all comparisons $p<0.001$). (Fig. 3b).

According to linear mixed model analyses, when sleep loss was considered as continuous, women with higher BMI (overall $p=0.049$; mid-pregnancy $p=0.018$, late pregnancy $p=0.011$) (Fig. 4b), multiparous women (overall $p<0.001$; early pregnancy $p<0.001$, mid-pregnancy $p=0.003$, late pregnancy $p<0.001$, delivery $p<0.001$; Fig. 4c), smokers (overall $p=0.047$; early pregnancy $p=0.020$; Fig. 4d), women who took naps ≥3 times/week (overall $p<0.001$; $p<0.001$ in all pregnancy points; Fig. 4e) and women with more depressive symptoms (overall $p<0.001$; early pregnancy $p=0.002$, mid-pregnancy $p<0.001$, late pregnancy $p<0.001$, delivery $p=0.003$; Fig. 4f) reported more sleep loss. There was no correlation between sleep loss and anxiety symptoms (overall $p=0.098$).

According to logistic regression analysis (Table 4), when sleep loss was considered as categorical using the cut-off point of >2 h/night, younger women were more likely to report sleep loss in early pregnancy. Women with higher BMI were more likely to report sleep loss in mid- and late pregnancy. Multiparous women were more likely to report sleep loss in early and late pregnancy. Women with high education were less likely to report sleep loss in early and mid-pregnancy. Smokers were more likely to report sleep loss in all other time points

then late pregnancy and women who took naps ≥3 times/week were more likely to report sleep loss at all time-points. Women with more depressive symptoms were more likely to report sleep loss in early and mid-pregnancy and at delivery, and women with more anxiety symptoms were more likely to report sleep loss in late pregnancy.

Discussion

According to our results, as expected, sleep duration was longest in early pregnancy and shortest at delivery, albeit the effect sizes were minimal. Of note was, instead, that the proportion of short sleepers (<6 hours) doubled in late pregnancy and almost quadrupled at delivery. The proportion of long sleepers (>10 h) remained unchanged. Interestingly, sleep loss showed an approximately opposite pattern than sleep duration, being lowest in late pregnancy but increasing again at delivery. Additionally, when sleep loss was considered as categorical, the proportion of women with notable sleep loss (>2 h) increased at delivery. Several associative factors emerged. Both short sleep and sleep loss were associated with multiparity, more frequent napping and depressive symptoms.

Previous studies have mainly agreed on a decrease in self-reported sleep duration throughout pregnancy; however, there are some differences in findings on actual sleep duration between previous studies [3, 4, 8, 21]. An earlier longitudinal study from Finland with 325 women found that mean sleep duration in the first trimester was 8.2 h, in the second trimester 8.0 h, and in the third trimester 7.8 h [4]. These figures are compatible with our findings. On the contrary, two studies from the USA present alternative findings. Facco et al. reported in their longitudinal study with 189 women, that the mean duration in the first trimester was 7.4 h and in the third trimester 7.0 h [3], and in the cross-sectional study of Mindell et al., the mean

sleep duration was 7.6 h in early pregnancy and 6.9 h in late pregnancy [8]. In addition, in a longitudinal study of 1,653 women by Yu et al from China, the mean sleep duration was 9.0 h in the first trimester, 8.7 h in the second trimester and 8.6 h in the third trimester [21]. Although these findings may suggest a cross-cultural differences in sleeping habits, differences in sample sizes and study methods may partly explain the variances in results.

More important than the sleep duration itself is whether sleep duration is extremely short or long, as both have been shown to be associated with adverse pregnancy outcomes such as gestational diabetes and pre-eclampsia [5] and short sleep duration with preterm labor, longer duration of delivery, and increased risk for operative delivery [5, 11, 12]. In addition, prolonged sleep duration has been shown to be associated with stillbirth [5]. In a previous study of 686 women from Singapore, 11.2% of the women reported sleep duration of <6 h/night in mid pregnancy [28]. Furthermore, in the above-mentioned study of Mindell et al, around 38% of women were short sleepers (≤6 hours) [8]. However, in that study, the women were enrolled via a pregnancy-related internet site, possibly leading to over-representation of short sleepers. These results differ considerably from ours, which are more in line with the findings of another sample from Finland, where 4.5% of pregnant women reported sleep duration of ≤6 h at gwk 32 [20].

Sleep deficiency (sleep loss) is defined as a deficit in the quantity or quality of sleep obtained versus the amount needed for optimal health, performance, and well-being [29]. In literature, sleep deficiency is often determined as short sleep duration, subjective perception of insufficient sleep, or insomnia. This complexity makes it hard to compare and interpret the previous studies. However, because sleep need is individual, sleep loss can be operationalized as a difference between sleep need and self-reported sleep duration. Furthermore, sleep loss could represent sleep problems more accurately than, for example, short sleep duration,

because some women are biologically short sleepers. Thus, focusing on sleep loss, we examined the difference between sleep need and self-reported sleep duration. To the best of our knowledge, there are no previous longitudinal studies evaluating sleep loss during pregnancy, making our study novel. We found that the mean sleep loss remained quite stable throughout pregnancy, but the proportion of women experiencing notable sleep loss increased at the end of the pregnancy. This might reflect an increase in insomnia symptoms [17] or other sleep disorders, like sleep disordered breathing [30] or restless legs syndrome [31], as reported in previous literature.

We found that older women slept less than younger women. This was in line with previous studies with smaller populations [4, 16]. In general, sleep duration is known to decrease with age, including during reproductive years [32]. In our study, there was a wide range in the age of the women, and some of the women were well over forty, which could at least partly explain our findings. Furthermore, we confirmed the previously reported shorter sleep duration in multiparous women [10]. Although we cannot provide a definite reason for shorter sleep duration in multiparous and older women, important practical causes that may limit sleep time include the care of previous children, household duties, illnesses, and medications.

Obesity is associated with worse sleep quality and sleep disturbances in the general population [33, 34]. However, there are fewer studies on these factors in the context of pregnancy. A longitudinal study from Singapore reported an inverse relationship between sleep duration and BMI in overweight but not in normal weight women during pregnancy [35]. In our study, higher BMI was associated with short sleep duration in late pregnancy, but not yet in the early or mid-pregnancy; this may be because the increase in weight is not typically pronounced until later in pregnancy.

Mental health issues can also affect sleep quality during pregnancy [7, 36]. A cross-sectional cohort study from China reported that women with mood disorders were more likely to report short sleep duration (≤6 h) in early pregnancy [19], and a study from Finland found that short sleep in late pregnancy was related to depression [15]. We confirmed these findings regarding depressive symptoms. Notably, our study adds to the literature that depressive symptoms at the beginning of pregnancy are associated with decreased sleep duration throughout pregnancy and more importantly, that women with depressive symptoms have greater sleep loss and higher probability to experience sleep loss greater than 2 h/night. In the earlier-mentioned longitudinal study from China, it was shown that short sleep duration (<8 h) increased the risk of depressive symptoms throughout pregnancy [21]. All data concerning this issue suggests that the associations between depression and sleep are bi-directional; depressive symptoms decrease sleep duration, but short sleep duration can also increase the severity of depressive symptoms. Screening for both sleep problems and depression during pregnancy is important because it could be possible to improve maternal wellbeing by supporting adequate sleep duration during pregnancy. In addition, maternal sleeping problems and short sleep duration are shown to increase the risk for postnatal depressiveness [6, 7], which can negatively affect both the mother and the offspring and interrupt, for example, postpartum bonding [37, 38]. Despite a clear connection between depressive symptoms and sleep, we could not confirm similar connection between anxiety symptoms and sleep. There can be several reasons for this finding. We assessed both depressive symptoms (EPDS) and anxiety symptoms (SCL) in early pregnancy. While depressive and anxiety symptoms were correlated, when analyzing their joint effect in a single model, depressive symptoms appeared more significant. As depressive symptoms were somewhat more profound than anxiety symptoms in early pregnancy, they may be more influential during this stage of pregnancy. However, anxiety symptoms may increase more as pregnancy proceeds, and thus, their role might be different by the end of pregnancy.

The strength of our study was its large cohort, which did not exclude women with co-morbidities or pregnancy complications. Thus, our results can be interpreted to represent the general pregnant population. By assessing sleep duration and sleep loss four times antenatally in a longitudinal study design, we were able to evaluate the changes throughout pregnancy. However, sleep was not measured pre-pregnancy, and therefore, we were not able to study any changes across the pre- and post-pregnancy periods. And furthermore, the women filled in the delivery point questionnaire after delivery. Although they were instructed to consider sleep quality over the previous month as with the other three measurement points, it is possible that their responses may have been somewhat biased due to the delivery; some women could have only considered their postpartum sleep quality. However, the vast majority responded within three days. Utilizing questionnaires in data gathering was feasible, since it permitted a large sample of women to participate, especially as participating through questionnaires is rather easy. Further, the questionnaires that we used are widely used in several different contexts, also during pregnancy [23–25, 27]. However, no objective sleep data were collected. The use of a subjective estimation of sleep might increase the risk of reporting bias, which we were not able to control. Nevertheless, any reporting errors were probably random and on average equivalent for all women. In addition, there are studies showing that subjective perception of sleep is a stronger predictor of, for instance, mood symptoms than actigraphy-assessed sleep [39, 40].

Conclusion

We confirmed earlier reported decrease in sleep duration at the end of pregnancy. Especially, the number of short sleepers quadrupled. Furthermore, as a novel finding, we showed that the proportion of women suffering from extreme sleep loss increased at the last month of

pregnancy. Various associative factors were identified, with multiparity being the most frequently observed maternal characteristic, along with maternal symptoms such as depressive symptoms and napping. Our findings are clinically important for several reasons. Firstly, shortening of sleep duration and especially sleep loss cause negative daytime consequences, such as sleepiness and decrease in cognitive performance and quality of life [41–43]. Secondly, previous literature has indicated that inadequate sleep duration, especially in late pregnancy, is associated with poor pregnancy and delivery outcomes [5]. And thirdly, but not least importantly, disturbed sleep may increase the risk for postpartum depression [7] and impair postpartum mother-child bonding [37, 38]. Therefore, sleep quantity and quality should be considered by healthcare providers during pregnancy and sleep disturbances treated as effectively as possible.

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Contributions:

Linda Aukia (ORCID iD 0000-0003-1930-2984) is the principal investigator and writer of the paper and co-leader of the present sub-study. Linnea Karlsson (ORCID iD 0000-0002-4725-0176) and Hasse Karlsson (ORCID iD 0000-0002-4992-1893) are the leaders of the FinnBrain study, co-investigators and co-writers. Juho Pelto (ORCID iD 0000-0001-8820-8014) and Laura Perasto (ORCID iD 0009-0003-3209-0506) are the statisticians of the study. E.Juulia Paavonen (ORCID iD 0000-0002-1421-9877) and Päivi Polo-Kantola (ORCID iD 0000-0003-0665-0306) are the leaders of the present sub-study, co-investigators and co-writers.

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Conflict of interest:

None.

Ethical approval

The study had approval of the Joint Ethics Committees of the University of Turku and Turku University Hospital, Turku, Finland (number 8/180/2010).

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Table 1. Gestational weeks and characteristics of the women

	n	Mean ± SD or %	Range
Early pregnancy time point (gwk)	2887	14+6 ± 7 d	12–18
Mid-pregnancy time point (gwk)	2287	25+1 ± 7 d	22–28
Late pregnancy time point (gwk)	2390	35+1 ± 7 d	32–38
Delivery time point (gwk)	1786	39+6 ± 10 d	0–7 d postpartum
Age (years)	3038	30.4 ± 4.5	17–46
BMI (kg/m^2)	2957	24.6 ± 4.8	15.6–60.6
Parity	3020		
Nulliparous	1561	51.7%	
Multiparous	1459	48.3%	
Education	3027		
Low level	1136	37.5%	
Middle level	881	29.1%	
High level	1010	33.4%	
Marital status	2942		
Married/Cohabiting		98.3%	
Divorced		0.4%	
Single		1.3 %	
Smoking, early pregnancy	378	12.7%	
EPDS score, early pregnancy	2990	5.2 ± 4.0	0-27
SCL score, early pregnancy	2992	3.3 ± 3.9	0-33

Abbreviations: gwk, gestational week; BMI, body mass index (kg/m^2); EPDS, Edinburgh Postnatal Depression Scale; SCL Symptom Checklist -90/Anxiety Scale; SD, Standard Deviation

Table 2. Factors associated with short sleep duration (<6 hours per night)

	Early			Mid			Late			Delivery		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Age[a]	1.11	1.03-1.20	0.007	1.09	1.01-1.17	0.031	1.06	1.00-1.12	0.042	1.05	1.00-1.11	0.040
BMI[a]	1.03	0.97-1.09	0.277	1.06	1.00-1.12	0.052	1.05	1.01-1.09	0.012	1.01	0.97-1.06	0.515
Parity												
multiparous vs nulliparous	1.10	0.56-2.16	0.787	1.47	0.72-2.99	0.288	1.41	0.84-2.35	0.191	0.80	0.52-1.24	0.314
Education												
mid vs low	1.25	0.53-2.91	0.610	0.79	0.35-1.78	0.567	0.73	0.41-1.28	0.273	1.60	0.95-2.72	0.079
high vs low	1.41	0.61-3.24	0.424	0.41	0.15-1.07	0.070	0.26	0.12-0.54	<0.001	0.96	0.54-1.72	0.889
Smoking												
yes vs no	2.43	1.10-5.38	0.028	1.83	0.80-4.18	0.152	1.40	0.74-2.64	0.307	2.33	1.35-4.03	0.002
Naps												
≥3 per week vs <3 per week	1.75	0.87-3.51	0.114	1.88	0.88-3.99	0.102	2.16	1.32-3.52	0.002	2.26	1.49-3.41	<0.001
EPDS[a]	1.11	1.02-1.21	0.013	1.09	1.00-1.20	0.063	1.02	0.95-1.10	0.544	1.04	0.98-1.11	0.193
SCL[a]	1.05	0.97-1.13	0.227	1.04	0.95-1.13	0.388	1.05	0.99-1.12	0.101	0.99	0.93-1.07	0.875

Abbreviations: BMI, body mass index (kg/m^2); EPDS, Edinburgh Postnatal Depression Scale;
SCL Symptom Checklist -90/Anxiety Scale.

Logistic regression model.

[a] Continious variables.

Table 3. Factors associated with long sleep duration (>10 hours per night)

	Early			Mid			Late			Delivery		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Age[a]	0.96	0.88-1.05	0.363	0.82	0.70-0.95	0.011	0.92	0.83-1.02	0.120	0.92	0.81-1.05	0.071
BMI[a]	1.01	0.95-1.08	0.720	1.06	0.97-1.16	0.197	1.01	0.92-1.10	0.885	0.99	0.89-1.10	0.888
Parity												
multiparous vs nulliparous	1.14	0.52-2.52	0.743	0.78	0.22-2.81	0.710	0.49	0.18-1.34	0.164	0.43	0.13-1.45	0.172
Education												
mid vs low	0.30	0.10-0.92	0.036	0.24	0.03-2.09	0.197	0.43	0.11-1.66	0.220	0.09	0.01-0.70	0.022
high vs low	0.41	0.15-1.11	0.080	1.07	0.26-4.49	0.926	1.05	0.36-3.04	0.926	0.27	0.07-1.08	0.064
Smoking												
yes vs no	0.56	0.19-1.67	0.296	0.28	0.03-2.24	0.228	0.99	0.31-3.15	0.991	0.19	0.02-1.49	0.114
Naps												
≥3 per week vs <3 per week	1.97	0.91-4.27	0.087	1.90	0.55-6.57	0.314	0.61	0.21-1.83	0.382	1.84	0.69-4.93	0.222
EPDS[a]	1.06	0.95-1.17	0.286	1.10	0.93-1.29	0.258	1.13	1.00-1.28	0.051	0.97	0.83-1.15	0.746
SCL[a]	1.05	0.96-1.15	0.279	0.97	0.83-1.13	0.704	0.95	0.84-1.08	0.449	1.09	0.95-1.26	0.212

Abbreviations: BMI, body mass index (kg/m^2); EPDS, Edinburgh Postnatal Depression Scale;
SCL Symptom Checklist -90/Anxiety Scale.

Logistic regression model.

[a] Continious variables.

Table 4. Factors associated with sleep loss (>2 hours per night)

	Early			Mid			Late			Delivery		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Age[a]	0.97	0.94-1.00	0.048	0.98	0.95-1.02	0.299	0.98	0.94-1.01	0.170	1.01	0.98-1.05	0.500
BMI[a]	1.01	0.99-1.04	0.289	1.04	1.01-1.07	0.004	1.04	1.01-1.07	0.004	1.01	0.98-1.04	0.348
Parity												
multiparous vs nulliparous	1.56	1.18-2.07	0.002	1.15	0.84-1.57	0.393	1.86	1.37-2.52	<0.001	1.14	0.84-1.54	0.407
Education												
mid vs low	0.90	0.65-1.24	0.510	0.86	0.59-1.25	0.418	0.89	0.62-1.28	0.541	1.19	0.84-1.69	0.335
high vs low	0.55	0.38-0.80	0.002	0.54	0.36-0.83	0.005	0.69	0.47-1.01	0.057	0.68	0.46-1.01	0.055
Smoking												
yes vs no	1.77	1.27-2.48	<0.001	1.79	1.21-2.64	0.004	1.45	0.97-2.16	0.068	1.53	1.02-2.30	0.041
Naps												
≥3 per week vs <3 per week	2.13	1.60-2.84	<0.001	1.73	1.20-2.49	0.003	1.66	1.23-2.25	0.001	1.67	1.25-2.22	<0.001
EPDS[a]	1.06	1.02-1.10	0.002	1.06	1.02-1.11	0.008	1.04	0.99-1.08	0.107	1.07	1.03-1.12	0.002
SCL[a]	1.03	0.99-1.07	0.155	1.01	0.97-1.06	0.554	1.05	1.01-1.09	0.016	1.00	0.95-1.05	1.00

Abbreviations: BMI, body mass index (kg/m^2); EPDS, Edinburgh Postnatal Depression Scale;
SCL Symptom Checklist -90/Anxiety Scale.

Logistic regression model.

[a] Continious variables.

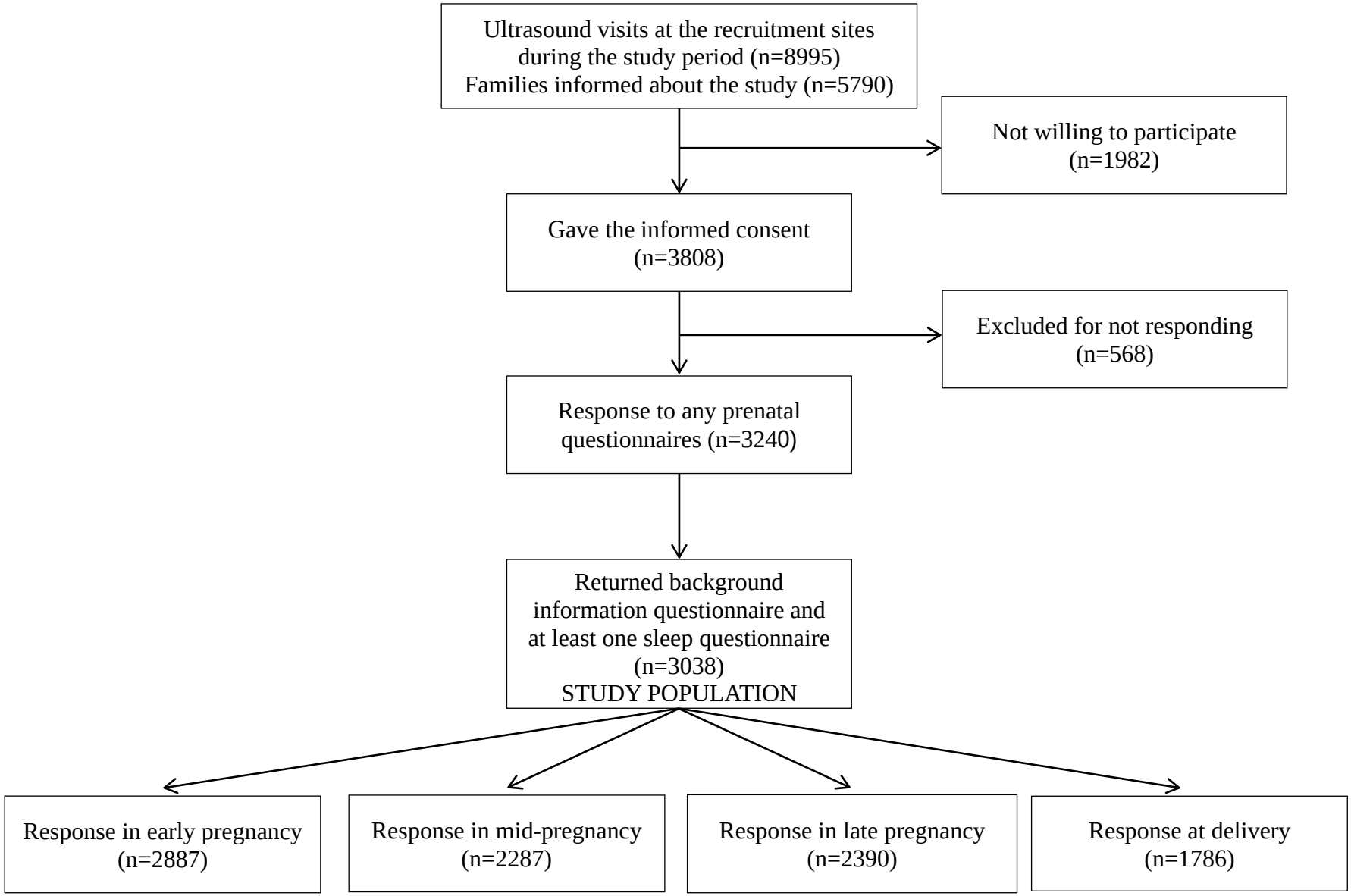


Figure 1. The flowchart of the study

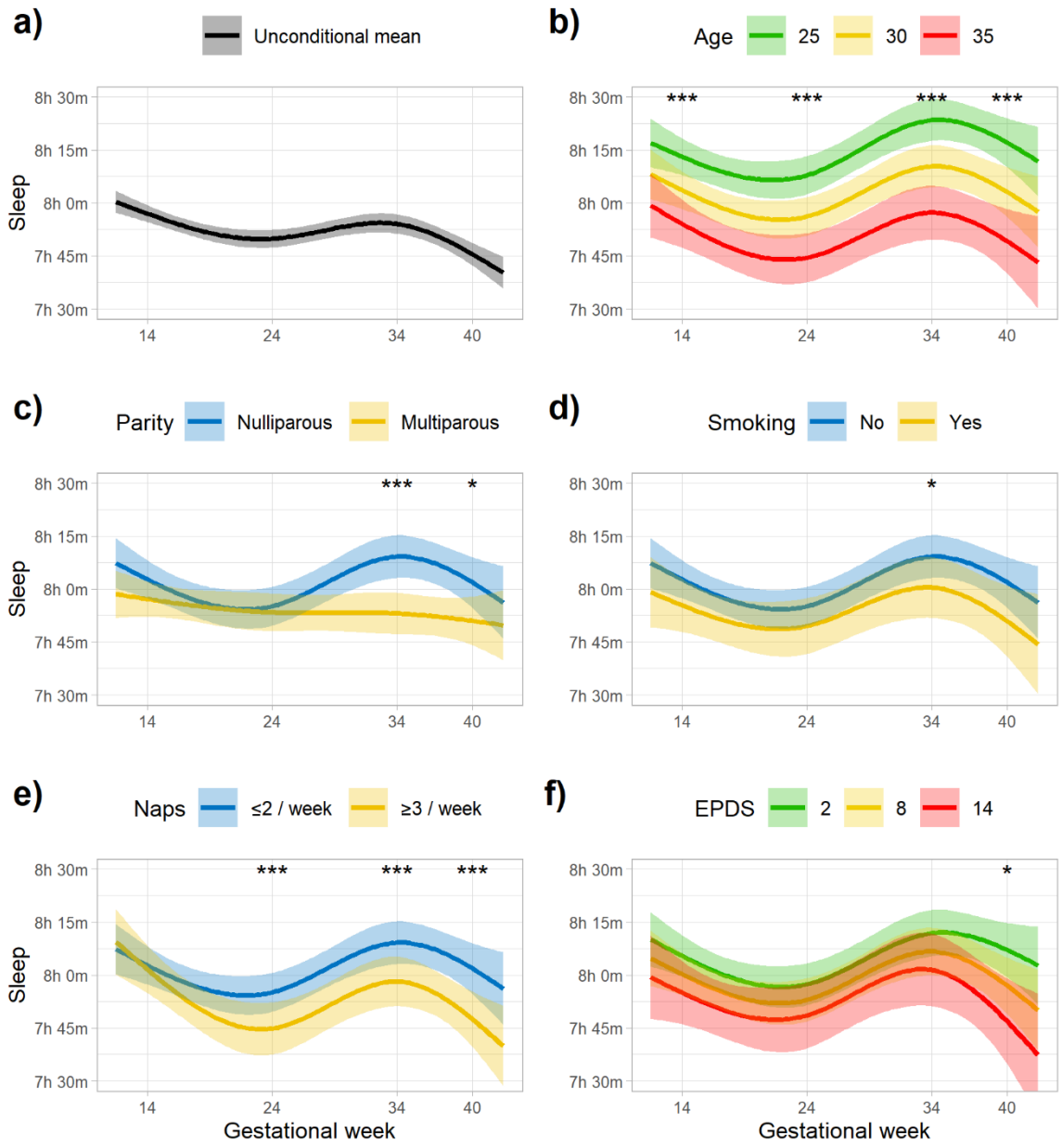
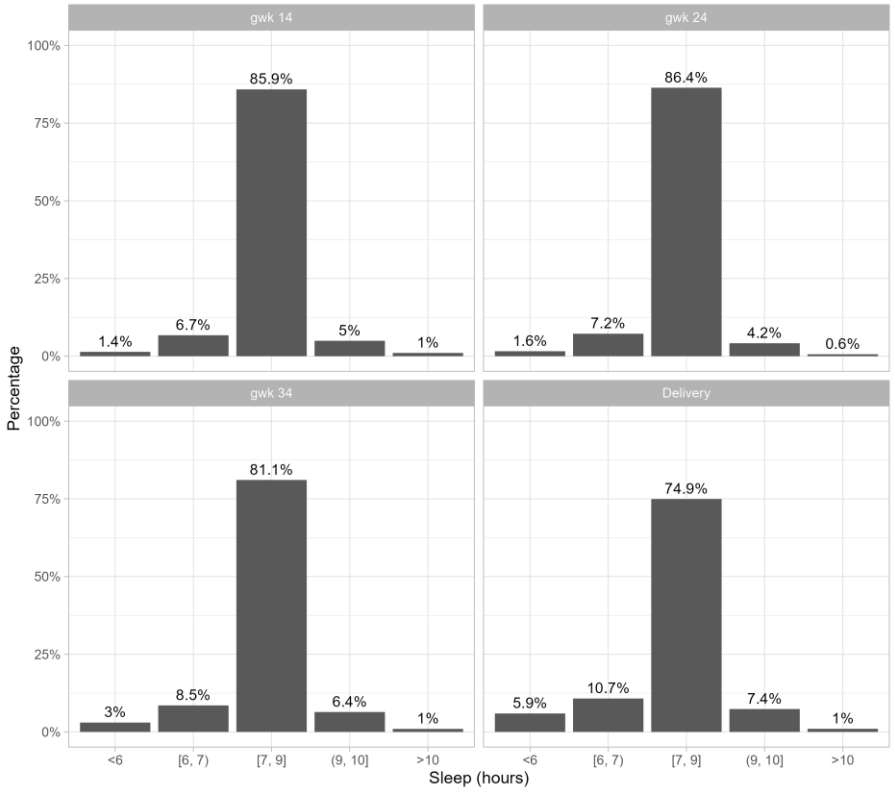


Figure 2. Sleep duration and associative factors.
P-values: *<0.05, **<0.01, ***<0.001. Cross-sectional comparisons, linear mixed model.

a)



b)

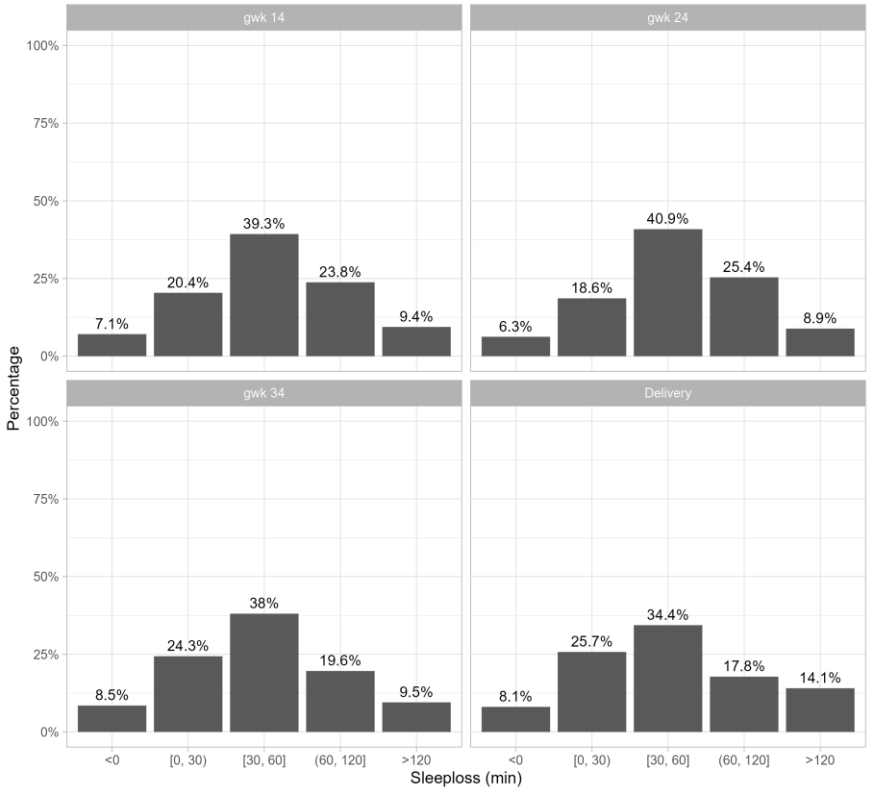


Figure 3. a) Percentages of women with various sleep duration categories (hours).
b) Percentages of women with various sleep loss categories. Sleep loss = sleep need.

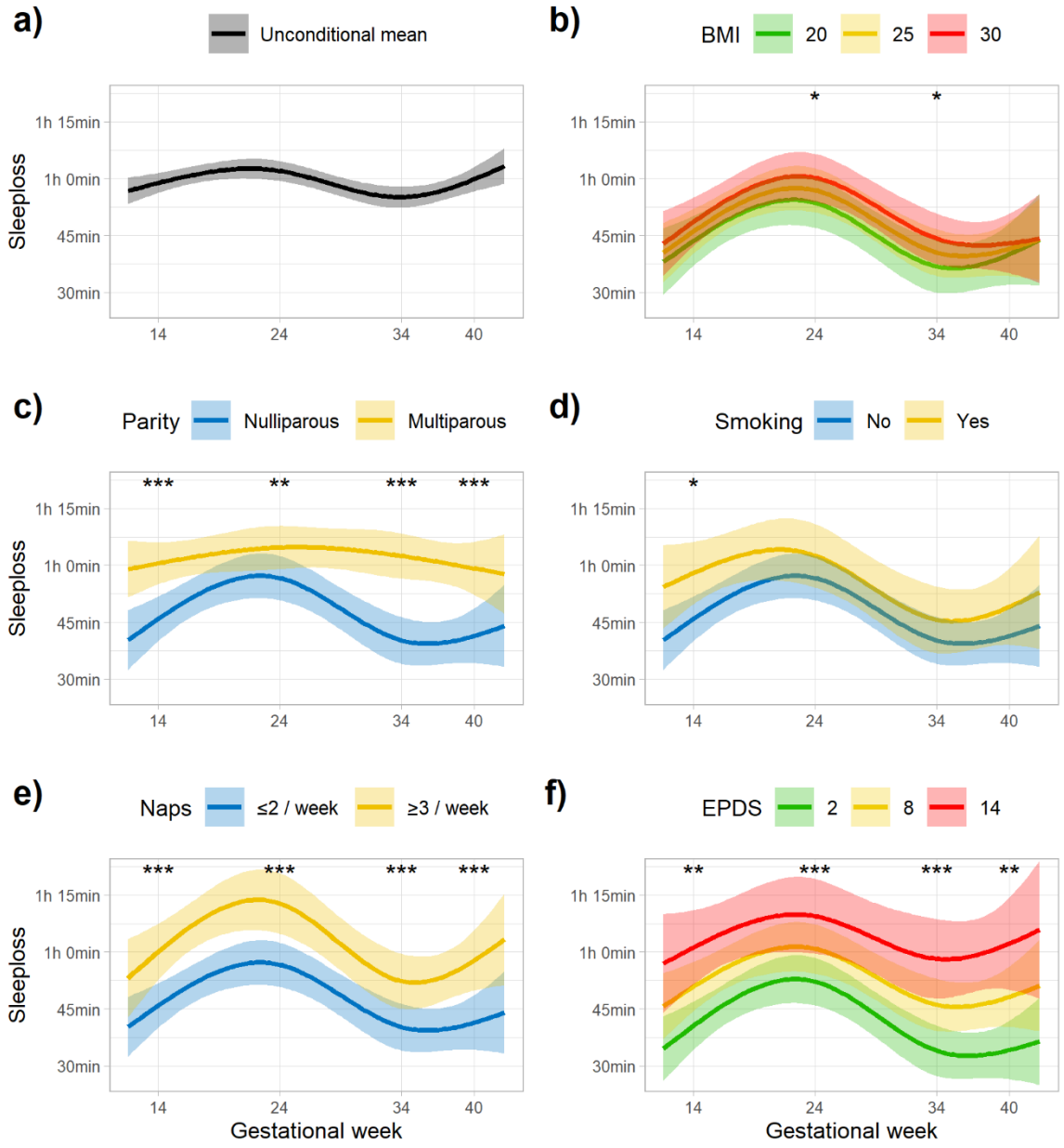


Figure 4. Sleep loss and associative factors.
P-values: *<0.05, **<0.01, ***<0.001. Cross-sectional comparisons, linear mixed model.