Sleep disturbances and depressive and anxiety symptoms during pregnancy: associations with delivery and new-born health

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Abstract

Background: Sleep disturbances and mood symptoms are common in late pregnancy and they contribute to the decline in daytime quality of health and life in expecting mothers. This study evaluated the effect of these disturbances on delivery and new-born health as these associations have been insufficiently covered in the previous literature.

Methods: A cohort of 1414 mothers was enrolled in the third trimester to this prospective cross-sectional questionnaire study. Basic Nordic Sleep Questionnaire was assessed for measurement of sleep quality and sleep length, Epworth sleepiness scale for sleepiness, the Center for Epidemiologic Studies Depression Scale for depression and State-Trait Anxiety Inventory for anxiety. The data on delivery and new-born outcomes was obtained from hospital medical records.

Results. Sleep disturbances were very common during pregnancy. Higher insomnia score (β = -0.06, p = 0.047) and longer sleep need (β = 0.07, p = 0.047) were related to delivery at a lower gestational age. In addition, higher insomnia score (β = -28.30, p = 0.010) and lower general sleep quality (β = -62.15, p = 0.025) were associated with lower birth weight. Instead, longer sleep duration and longer sleep need with higher birth weight (β = 28.06, p = 0.019; β = 27.61, p = 0.028, respectively). However, these findings regarding birth weight lost their significance when the birth weight was standardized with gestational weeks. Snoring was associated with a shorter duration of the 1st phase (β = -78.71, p = 0.015) and total duration of delivery (β = -79.85, p = 0.016). Mothers who suffered from high insomnia, depressive or anxiety symptoms were more often treated with oxytocin (OR 1.54 95% CI 1.00-2.38, p = 0.049, OR 1.76, 95% CI 1.02-3.04, p = 0.049 and OR 1.91, CI 95% 1.28-2.84, p < 0.001, respectively) and very depressive and anxious mothers delivered more often with elective caesarean section (OR 4.67, 95% CI 2.04-12.68, p < 0.001 and OR 2.22, 95% CI 1.03-4.79, p = 0.042).

Conclusions: Maternal sleep disturbances and mood symptoms during pregnancy are associated with delivery and new-born health. However, in this normative sample nearly all the outcomes fell within a normal range, implying that the actual risks are low.

Background

Pregnant women sleep poorly [1]. Sleep disturbances, especially insomnia symptoms, are common during pregnancy and often worsen towards the end of the pregnancy [2–5]. Insomnia symptoms, including difficulties to fall asleep (initiation insomnia), nightly awakenings and too early morning awakenings (maintenance insomnia) lead to decreased sleep efficiency, decreased sleep time and poor overall sleep quality [6]. Occurrence of sleep disordered breathing (snoring, sleep apnoea and partial upper airway obstruction) and restless legs syndrome also increase during pregnancy [5, 7]. Fatique, tiredness, morning and daytime sleepiness and napping are common consequences of sleep disturbances.

Sleep disturbances and poor sleep quality are reported to influence pregnancy outcomes, as well as to impair the health of the mother and the new-born [8–10]. Some evidence suggest that poor sleep quality and short sleep duration during pregnancy may also increase the risk of operative deliveries, especially of caesarean section [11–13]. Previous studies indicate that sleep disturbances could also be associated with a longer duration of delivery and more importantly, with adverse neonatal outcomes, such as lower birth weight and lower Apgar scores [12, 14]. However, the literature is sparse, and the evidence on this matter is still controversial as according to some other studies [15, 16] there is no association between sleep quality and pregnancy outcomes. This could be the result of a lack of power and an inadequate control of the confounding factors in the previous studies.

Low sleep quality and short sleep duration during pregnancy and during the postpartum period are known risk factors for depressive and anxiety symptoms and vice versa [17–20]. Furthermore, pregnant mothers with mood symptoms are at a higher risk of postpartum depression and at a risk of having problems in forming a healthy mother-child relationship [21]. Depressive and anxiety symptoms have also been linked with a higher occurrence of caesarean section and adverse neonatal outcomes in one study [22], but contradictory findings have also been presented [16, 23, 24]. Therefore, more studies are needed to evaluate how sleep disturbances and depressive and anxiety symptoms are related to pregnancy complications. Consequently, the aim of our study was to evaluate the effect of maternal sleep disturbances, sleep time and mood symptoms on delivery and new-born health. We concentrated on insomnia symptoms, sleep deprivation and sleepiness symptoms, as well as depressive and anxiety symptoms. We hypothesized that both sleep disturbances and mood symptoms would result in delivery complications and relate to poorer health in the new-born.

Methods

Subjects

This prospective study was a part of a Finnish CHILD-SLEEP–birth cohort, which has been described in detail by Paavonen et al. [25]. Mothers were recruited by midwives or nurses in maternity clinics in the Pirkanmaa area during routine pregnancy-related check-ups in approximately the gestation week (gwk) of 32. All of the participants were given both oral and written information about the study. The mothers were eligible if they were willing to participate in the study, had sufficient language skills (Finnish) to complete the study questionnaires and if they gave their written consent to take part in the study. Altogether 1673 women participated in this study.

Mothers who had an incomplete questionnaire, missing delivery or new-born data or who had completed the questionnaire before gwk 24 or after the delivery were excluded (n = 116). The mothers filled in the questionnaire on average in the gwk 35 (range 24–41). Since the delivery outcomes were of especial interest in our study, we also excluded twin pregnancies (n = 10) and pregnancies with a foetus in other than a cephalic presentation (n = 58). Thus a final sample of 1414 women remained to form the study population. The mothers were recruited between April 2011 and December 2012, and the infants were

born between April 2011 – February 2013. During that time period, approximately 7700 infants fulfilling the inclusion criteria were born in the target area, but due to the exclusion criteria, maternal denials, language, and a failure on the prenatal nurses' part to present the survey to the mothers, the sample coverage was approximately 20% (Fig. 1).

Basic characteristics are shown in Table 1. Sociodemographic factors included age (years), parity (nulliparous/multiparous) and education (low [no education or vocational training]/mediate/high [university]). Health behaviour factors included body mass index at the time of the survey (BMI, kg/m^2) and smoking (yes/no). Questions about the participant's state of health comprised of the existence of a long-term disease/disability (yes/no; if yes, specify) and the use of a regular medication (yes/no; if yes, specify). Of the mothers, 1102 (77.9%) considered themselves healthy and 305 (21.6%) reported having one or more diseases or disabilities, such as diabetes, hypothyroidism, rheumatic diseases, inflammatory bowel disease, asthma and allergy, epilepsy, migraine, depression or anxiety. Replies to this question were missing for 7 (0.5%) mothers. Of all mothers, 367 (26.0%) reported using regular medication, such as insulin, thyroxine, corticosteroids (mainly inhaled), antihistamines, anti-convulsive medications or antidepressants (mainly selective serotonin reuptake inhibitors). Furthermore, 808 (57.1%) had used some medication occasionally or periodically during pregnancy (e.g. antibiotics, paracetamol, labetalol, ursodeoxycholic acid and low-molecular-weight heparin).

Questionnaires

The sleep quality and sleep duration were evaluated with eight questions drawn from the Basic Nordic Sleep Questionnaire (BNSQ) [26] (general sleep quality, difficulties to fall asleep, nightly awakenings per week, number of awakenings per night, too early awakenings, snoring, sleep duration, sleep need) and were assessed for the past month. General sleep quality was rated with on 5-point scale as 1 = 'good', 2 = 'quite good', 3 = 'intermediate (neither good nor poor)', 4 = 'quite poor' or 5 = 'poor' and the other questions with a 5-point scale as 1 = 'never or less than once a month', 2 = 'less than in one day a week', 3 = 'in one or two days a week', 4 = 'in three to five days a week' and 5 = 'daily or almost daily', and in the question regarding frequency of nocturnal awakenings per night 1 = 'none', 2 = 'once', 3 = 'twice', 4 = 'three to four times', 5 = 'at least five times'. To represent the severity of co-operative action of all the insomnia symptoms (general sleep quality, difficulties to fall asleep, nightly awakenings per week, number of awakenings per night, too early awakenings), a summary score was defined by dichotomizing the responses (0 = '1–2 times per week/night or less' vs 1 = '3–5 times or more per week/night'), and the scores were totalled to form a insomnia score (range 0–5 points). Score of 4 points or more was considered deviant. In addition, perceptions of sleep quality alterations were investigated with the question: 'Have your sleep quality altered during pregnancy compared to the time before pregnancy' (response options; 'clearly better'/'better'/'no change'/'worse'/'clearly worse') Sleep duration (h) was calculated as the average self-reported sleep time during weekdays and weekends and the sleep need as self-reported desired sleep time. In case the sleep times ranged over 2 hour, the reply was excluded. Sleep loss was defined by subtracting sleep need from sleep time. Sleep duration < 6 hours and sleep loss > 2 hours were defined deviant.

Sleepiness symptoms were evaluated with the Epworth Sleepiness Scale (ESS) [27], in which on a 4-point scale the subjects rates their likelihood to fall asleep during normal daily activities. A higher ESS sum score (maximum score 24) indicates more severe symptoms and sleepiness was considered deviant, when the sum score was ≥ 11. In addition, morning tiredness was assessed with the question 'During the first half-hour after you wake up in the morning, how tired do you feel?' ('very well rested'/'rested'/'tired'/'very tired') and daytime tiredness with the question 'Are you more tired during daytime than the most of the people of your age?' ('not at all'/'often'/'always'/'can't say').

Depression was evaluated using the shortened Center for Epidemiologic Studies Depression Scale (CES-D) [28] with ten questions in a scale from 0 to 3 in each question (range 0–30). Scores were totalled to form a depression score; total score ≥ 12 points (95th percentile) was used as a cut-off point.

A shortened Spielberger Trait Anxiety Inventory (STAI) [29] was used to evaluate anxiety with six questions in a scale from 1 to 4 in each question (anxiety at all times and the person's vulnerability to anxiety). Scores were totalled to form an anxiety score; total score ≥ 12 (95th percentile) was used as a cut-off point (range 6–24).

Data of delivery and new-born health

The data of the delivery and new-born health were collected from hospital medical records and hospital register data. Maternal birth variables included gestational weeks (gwks) at the time of delivery, the type of delivery (spontaneous vaginal/vacuum delivery/elective caesarean section/acute caesarean section), the use of oxytocin during delivery (yes/no), duration of delivery (phase I [min], phase II [min], total duration [min]) and medical pain relief during delivery (none/nitrous oxide/para cervical or pudendal block/epidural and/or spinal anaesthesia). If multiply anaesthesia was used, only the most effective was taken into account. The new-born variables were weight (grams), standardised birth weight, length (cm), standardised birth length, head circumference (cm), standardised birth head circumference, Apgar scores (at 1 minute and 5 minutes), and pH of the umbilical artery (uApH) and umbilical vein (uVpH) at birth.

Statistical analyses

Sleep variables, depressive and anxiety symptoms, delivery and new-born variables and basic characteristics were first submitted for descriptive analysis and were expressed as means and standard deviations (SD) and ranges or frequencies (numbers and percentages). Insomnia total score, sleep duration, sleep loss, ESS (sleepiness score), CES-D total score (depression score) and STAI total score (anxiety score) were used both as continuous and dichotomous variables (Cut off points: Insomnia score ≥ 4, sleep duration < 6 hours, sleep loss > 2 hours, ESS ≥ 11, CES-D ≥ 12, STAI ≥ 12). Sleep need was considered as continuous and snoring as dichotomized (no = '1–2 times per week/night or less' vs yes = '3–5 days or more a week'). Maternal age and BMI were considered as continuous. Delivery variables were considered as categorised, except for gestational weeks (gwks), which were calculated as continuous. New-born variables were considered as continuous, except for the Apgar scores, which were categorised as ≤ 7 or > 7 (both at 1 minute and 5 minutes).

Finally, we conducted a series of regression models to control for potentially confounding background factors (age, parity, BMI, general health, smoking and education). Linear regression models were used to study factors related to gestational age, birth weight and standardised birth weight, duration of delivery (phases I and II and total duration) and birth variables (Apgar scores at 1 and 5 minutes and uApH). Logistic regression was used to study the risk of oxytocin use and elective caesarean section. The cases with caesarean section were excluded from the models where birth variables or duration of delivery were studied (the *n* in the models varied 1258–1268).

In the modelling, each explanatory factor was studied separately to control for the confounding factors in the statistical models. *P*-values of < 0.05 were considered as statistically significant and are bolded in the tables. Statistical computations were performed using SPSS Statistics 26 data program.

Results

Maternal sleep quality and mood symptoms

As reported earlier by Paavonen et all. [25] from the same cohort: the total sleep duration average in the cohort was normal, approximately 8 hours, but varied greatly with 19.0% of the women sleeping for < 7 hours per night and 4.2% <6 hours. A sleep loss of > 2 hours was uncommon. The frequencies of reported sleep disturbances, sleepiness and tiredness symptoms, as well as depressive and anxiety symptoms are described in Tables 2–3. Compared to the pre-pregnancy time, sleep quality had worsened during pregnancy for 83.2% of the women. The most common sleep disturbance was nocturnal awakenings, with 98.4% of the mothers experiencing this weekly and 83.3% daily.

Delivery and new-born outcomes

Of all mothers, 98.4% had a full term pregnancy (≥ 37 gwk, range 33–42) and 82.3% delivered vaginally. Of the operative deliveries, the caesarean section rate was 10.0% and the vacuum extraction rate 7.6%. The most common pain relief used was epidural and/or spinal anaesthesia. Oxytocin was used in over half of deliveries (Table 4).

Of all the new-borns, 1.2% (*n* = 19) had a standardised birth weight under − 2 and 2% (*n* = 28) over + 2. UApH was normal in most cases of the new-borns: 3.2% (*n* = 45) had a uApH < 7.10 and only 0.1% (*n* = 2) uApH < 7.00. The vein pH was available only in 203 new-borns and it was thus not included in the analysis. The 1 minute Apgar scores were < 7 in 3.1% (*n* = 44) and the 5 minutes Apgar scores were < 7 in 0.1% (*n* = 4). The new-born data is shown in Table 4.

Associations between maternal sleep quality and mood symptoms and delivery outcomes

Mothers with a higher insomnia score delivered at lower gestational age (Table 5); a one point increase in the insomnia score shortened the duration of pregnancy, on average, by approximately 0.5 day (0.06

week). In addition, longer sleep need was associated with 0.5 days longer duration of pregnancy (Table 5). The results remained after controlling for the other sleep variables and mood symptoms. However, the mean gwk at delivery fell within the normal range in the entire sample. Snoring was associated with a shorter duration of phase I and a shorter total duration of the delivery. Sleep loss instead was associated with longer duration of phase 1 and longer total duration of the delivery (Table 6). A high level of insomnia score ≥ 4, a high level of depression score (≥ 12 [95th percentile] in CES-D total score) and a high level anxiety score (≥ 12 [95th percentile] in STAI total score) were related to higher odds for being treated with oxytocin during delivery and depressive and anxiety scores with higher odds for elective caesarean section (Table 7). No other associations with delivery outcomes emerged.

Associations between maternal sleep quality and mood symptoms and new-born outcomes

Mothers with higher insomnia scores and lower general sleep quality delivered smaller infants (Table 5). Furthermore, those with longer sleep duration and longer sleep need delivered infants with bigger weight. However, when the gestational week at delivery was taken into account in birth weight calculation using standardized birth weight as outcome, all these findings lost the statistical significance (Table 5). Concerning Apgar scores and the uApH, no associations between the variables were found (data not shown). All the above-mentioned results remained when the other sleep variables and mood symptoms were taken into account in the statistical modelling (data not shown).

Discussion

In our sample, comprising of late gestational week pregnancies, both insomnia and sleepiness symptoms were common. As described earlier in this article, we found some specific correlations between insomnia symptoms and poor sleep quality and delivery and newborn outcomes. Higher depressive symptoms and higher anxiety symptoms were also associated with delivery and with the use of oxytocin, the latter being a novel finding. However, the absolute risks related to insomnia and mood symptoms were small and thus their clinical significance remains to be evaluated in further studies. Yet, sleep disturbances and mood symptoms are a major health issue during pregnancy and thus should be considered as risk factors for delivery and newborn health.

Emerging evidence indicates that maternal sleep disturbances, especially poor sleep quality, short sleep duration and sleep disordered breathing may contribute to maternal morbidity and adverse outcomes in pregnancy, such as preterm delivery. In a study of 166 mothers by Okun and colleagues [30] poor sleep quality especially in early pregnancy (14–16 weeks), but also with a tendency in late pregnancy, was a predictor of preterm birth. We found that higher insomnia symptoms were associated with delivery in lower gestational weeks, even though our sample was recruited relatively late in the third trimester. Therefore, in our study, the absolute risk related to insomnia seemed to be lower than the risks reported earlier while the effect of insomnia symptoms already starting in early pregnancy and especially those lasting throughout pregnancy remains unanswered. Thus, more studies are needed, particularly using

follow-up samples starting from early pregnancy. We found that higher sleep duration and sleep need were associated with slightly longer duration of pregnancy and this finding supports the thought of better sleep leading to a better pregnancy outcome. Of note is that sleep loss, calculated by subtracting sleep need from sleep duration, was not associated with any delivery or new-born variables.

Prior research concerning antenatal sleep quality and duration of delivery is limited and controversial. Insomnia symptoms and short duration of sleep, especially during the last trimester, have been suggested to predispose to a longer duration of delivery [12, 13] and a higher risk of operative deliveries [11, 12, 31]. In an Iranian study of 457 primiparas in gwk 37 [12], short sleep duration was associated with a longer duration of all the phases of delivery, whereas worse sleep quality only with a longer duration of the third phase of delivery. Similar results were gained in another Iranian study with 88 mothers whose sleep quality was assessed three weeks prior to delivery [13]. We found somewhat similar results; higher sleep loss (actual total sleep time subtracted from desired sleep need) was associated with longer first phase and total time of the delivery. On the other hand, in our study, neither sleep disturbances nor total sleep duration were associated with the length of delivery. This is consistent with a Canadian study with 624 mothers [16], and in an American study with 99 mothers [32] which found no effect of sleep loss on the duration of delivery. One explanation for inconsistencies in results could be the various definitions in the duration of delivery and differences treatment protocols between the countries.

Concerning the mode of the delivery, in the group of 131 American mothers [11], sleeping less than six hours per night one week before delivery was a risk factor for an unplanned caesarean section. Moreover, the two above described Iranian studies [12, 13] found that both low sleep quality and short sleep duration in the third trimester were risk factors for caesarean section. In a large Swedish study [33], the researches screened retrospectively the electronic perinatal records of 6467 primiparas for free-text words that indicated stress, sleep disturbances and worry, and found that the existence of these words in the charts predicted an increased risk for an emergency caesarean section. In addition, in a Taiwanese study of 120 mothers [31], poor sleepers in the third-trimester were more likely to have a vacuum-assisted delivery. We could not confirm the associations between sleep disturbances and caesarean section, neither elective nor acute, which is in line with the results of two earlier mentioned Canadian and American studies [15, 16]. Of note is, that assessment of sleep disturbances in previous studies has varied widely and structured sleep questionnaires, as used in our study, have been utilized rarely.

Snoring becomes more common during pregnancy probably due to increased weight, oedema, and nasal congestion [34]. Habitual snoring is a known marker for sleep disordered breathing and it can affect maternal and new-born health by raising the risk of pre-eclampsia [8, 10], gestational diabetes [35] and low birth weight [10, 34]. According to our results, snoring was associated with delivery duration, however, in contrast to our expectations, it was associated with a shorter delivery duration, even though we controlled for maternal BMI, smoking, parity and weight of the newborn. The reason for this finding is unclear and its meaning remains uncertain. Nevertheless, snoring did not relate to other delivery or new-born outcomes. In a large American study of 1673 mothers, snoring during pregnancy was associated not only with a lower new-born birth weight but also with a higher risk of an elective and emergency

caesarean section [34]. In another study [36], however, no association between snoring and delivery was found. Comparing previous studies is challenging, as the methodology varies between the studies.

Prior studies concerning sleepiness and tiredness during pregnancy and their relation to delivery are sparse. In an American study of 1000 mothers, the mean ESS score was higher only among women delivering via elective caesarean section [37]. In a Taiwanese study of 633 low risk mothers, higher fatigue scores predicted caesarean deliveries [38]. In our study, sleepiness or tiredness did not correlate with delivery or neonatal outcomes.

Mood symptoms prior to delivery have been reported to increase the risk of emergency caesarean section [39]. We confirmed that severe mood symptoms, both depressive and anxiety symptoms, were associated with elective caesarean section: mothers with higher depressive score had an almost five times and mothers with higher anxiety scores an over two times higher incidence. In Finland fear of childbirth is one of the leading indications for an elective caesarean section. Mood symptoms anxiety and depression co-exist often with the fear of child birth [22], and willingness to undergo a caesarean section among these mothers is common. However, probably because of the low number of emergency caesarean in our study, that association was not found. Furthermore, the importance of our finding was notable, especially since the caesarean section rate in our study was low as the sample was recruited at the third trimester and breech and twin pregnancies were excluded. The overall elective caesarean section rate in Finland was 6.6% in 2018 (thl.fi).

High insomnia, high depressive score and high anxiety score correlated with the use of oxytocin during delivery. These findings were novel ones. Oxytocin causes the contractions of the uterus during delivery and stimulates lactation [40]. It also plays an important role in increasing maternal-foetal trust and bonding and modulates fear, stress and anxiety [41]. Anxiety which occurs in the third trimester and during delivery has been shown to have negative effects on the duration of all the phases of delivery [42]. In addition, in a recent large retrospective study women exposed to additional oxytocin during delivery were at a higher risk for the development of postpartum depressive and anxiety disorders [43]. Mood symptoms often co-exist with insomnia, so the finding of all these symptoms leading to the need of oxytocin is rational. It is possible that pregnant women suffering from insomnia or mood symptoms have lower levels of oxytocin during delivery or they have a decreased binding ability of oxytocin to the uterine oxytocin receptors and therefore these women need additional oxytocin stimulus. However, the use of oxytocin during delivery is also dependent on the physician and mid-wife policy and can vary widely. As oxytocin is important in maternal-foetal bonding and presumably is lower in mothers with anxiety, more research is needed to better understand the possible associations.

There are few studies addressing the relationship between maternal sleep and mood symptoms and neonatal outcomes, and most of these studies concentrate on maternal sleep duration. Sleep loss has been shown to negatively affect fetal growth and lead to a lower birth weight [14]. We found that higher insomnia scores and lower general sleep quality was associated with lower birth weight and longer sleep duration and longer sleep need with slightly higher birth weight. Nevertheless, when the birth weight was

standardized with gestational age at delivery, all of these associations vanished. These findings emphasized the importance to control for gestational length when studying birth weight. It has also been hypothesised that as a consequence of the suboptimal prenatal environment, the foetus has less resources at birth, resulting in lower Apgar scores [8]. Again, according to the Iranian study with 457 participants, mothers sleeping less than eight hours per day in the third trimester have shown to deliver neonates with lower Apgar scores compared to mothers sleeping longer [12]. Nonetheless, in that study, the clinical relevance of the finding remained unclear, since the Apgar scores of the new-born of short sleeping mothers fell within the normal range. In our study, no clinically relevant correlations emerged. This was true also in a Chinese study with 248 women and in a Canadian study with 650 mothers, where no correlations between maternal sleep variables and neonatal outcomes were found [16, 31]. However, of note is, that our study did not consider the effect in the case of very preterm newborns.

Our study comprised of a large sample of pregnant Finnish women recruited during the third trimester and delivery and new-born data drawn from registers. Based on validation studies, the accountability and coverage of the Finnish health care register data are high and reliable [44]. We used BNSQ and ESS questionnaires, which have been shown to be valid and reliable and have been used in similar studies earlier. However, there were limitations to the study. In our cohort, the caesarean and vacuum assisted delivery rates were lower than in the general population in Finland and therefore there might be a selection bias in the results. Concerning the caesarean, the main reason for the low rate was the exclusion of breech presentation, twin pregnancies and very preterm deliveries. The study assessed maternal sleep over the past months before delivery and can therefore reliably present only the effect of sleep in late pregnancy. The study was based on subjective questionnaires and no objective sleep data was collected. It is known that objective measurements of sleep can differ considerably from subjective self-reported sleep. Nevertheless, the report errors were probably randomly distributed and thus equivalent for all of the participants. In addition, our cohort comprised of women delivering mainly full term and thus our study did not consider the effects in the case of very preterm newborns, so the results cannot be interpreted in preterm cases.

Conclusions

Our data supported the earlier findings of a high frequency of sleep disturbances and mood symptoms during pregnancy [20, 25]. However, although we found statistically significant associations between both the sleep quality and mood symptoms and delivery and new-born outcomes, the absolute risks were small. Although this finding can be considered favourable, it is important to notice that maternal sleeping problems and mood symptoms are clinically highly relevant regarding for example maternal subjective wellbeing and risk for post-partum depression. There are good medical treatment options of sleep and mental symptoms that should be available when the women suffer from these symptoms during pregnancy. However, it might ease the burden of stress related to course of pregnancy to know that risk related insomnia, depressive and anxiety symptoms on delivery and new-born appear to be small. Finally, it is of note that our data represented only symptoms in late pregnancy and thus our results cannot be

extrapolated in the situation of mothers with long term insomnia and mood symptoms. Therefore, future studies recruiting mothers in early pregnancy or even before pregnancy are needed.

Abbreviations

BNSQ: Basic Nordic Sleep Questionnaire; BMI:body mass index; CES-D:Center for Epidemiologic Studies Depression Scale; ESS:Epworth sleepiness scale; gwk:gestational week; STAI:State-Trait Anxiety Inventory.

Declarations

Ethical approval:

The Study protocol was approved by Pirkanmaa Hospital District Ethical Committee (9.3.2011, ethical research permission code R11032). In addition, permission for recruitment procedure was also requested from the leading physicians of the 20 target health centres in Pirkanmaa area. All the participants gave a written consent.

Concent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from the Finnish Institute for Health and Welfare but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of The Finnish Institute for Health and Welfare.

Competing interests:

All authors have no conflicts of interest pertaining to this manuscript. Additionally, all authors declare that they have contributed to this manuscript.

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Authors' Contributions:

Hilla Peltonen is the principal investigator and writer of the paper. Juulia E. Paavonen is a co-investigator and co-writer and major contributor in the statistical analyses. Tiina Paunio and Outi Saarenpää-Heikkilä

are co-investigators in the larger Child-Sleep Study and Tero Vahlberg is a statistician consulted during the writing. Päivi Polo-Kantola is the leader of the study, co-investigator and co-writer. All authors read and approved the final manuscript.

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Tables

Table 1 Maternal **characteristics**

	n	Mean (SD) or %	Range
Age (years)	1411	30.6 (4.6)	17-48
BMI (kg/m^2)	1376	28.4 (4.4)	19.2-47.6
Vocational education	1382		
None or some vocational training	99	7.2 %	
Vocational degree or polytechnic	797	57.7 %	
University	486	35.2 %	
Parity	1319		
Nulliparous	612	46.4 %	
Multiparous	707	53.6 %	
Smoking during pregnancy	1409		
Yes	84	6.0 %	
Long term disability or illness	1414		
Yes	305	21.6 %	

BMI body mass index

Table 2 Maternal sleep disturbances and mood symptoms

	n	Mean (SD) or %	Range
Sleep duration (min)	1408	484 (63)	180-720
Sleep duration <7 hours	268	19.0 %	
Sleep duration <6 hours	59	4.2 %	
Sleep need (min)	1403	529 (60)	300-1140
Sleep loss (min)	1398	45 (63)	-240-+600
Sleep loss >2 hours	100	7.2%	
Insomnia score	1406	1.8 (1.1)	0-5.0
Sleepiness score (ESS)	1414	5.5 (2.7)	0-17.0
Depression score (CES-D)	1410	5.2 (3.5)	0-23.0
Anxiety score (STAI)	1413	9.0 (2.4)	6-21.0

CES-D Center for Epidemiologic Studies Depression Scale, *ESS* Epworth sleepiness scale, *STAI* State-Trait Anxiety inventory,

Table 3 Maternal sleep quality

	total n	*n (%)*	*n (%)*	*n (%)*	*n (%)*	*n (%)*
		Never or less than once a month or night	**Less than one day a week or night**	**On 1-2 days a week or night**	**On 3-5 days a week or night**	**Daily or almost daily**
Difficulties to fall asleep	1414	495 (35.0%)	428 (30.3%)	295 (20.9%)	133 (9.4%)	63 (4.5%)
Awakenings per week	1413	4 (0.4%)	14 (1.0%)	57 (4.0%)	160 (11.3%)	1178 (83.4%)
Awakenings per night	1408	23 (1.6%)	394 (28.0%)	490 (34.8%)	436 (31.0%)	65 (4.6%)
Too early awakenings	1413	507 (35.9%)	454 (32.1%)	305 (21.6%)	114 (8.1%)	33 (2.3%)
Snoring	1360	831 (61.1%)	196 (14.4%)	142 (10.4%)	69 (5.1%)	122 (9.0%)
Sleeping pill consumption	1414	1407 (99.5%)	2 (0.1%)	1 (0.1%)	2 (0.1%)	2 (0.1%)
Daytime naps	1411	254 (18.0%)	352 (24.9%)	438 (31.0%)	238 (16.9%)	129 (9.1%)
		Well	**Quite well**	**Indermediate**	**Quite poor**	**Poor**
Sleep quality	1414	194 (13.7%)	550 (38.9%)	284 (20.1%)	330 (23.3%)	56 (4.0%)
Sleep quality alteration		**Clearly better**	**Better**	**No Change**	**Worse**	**Clearly worse**
	1402	4 (0.1%)	36 (2.6%)	195 (13.9%)	810 (57.8%)	357 (25.5%)
Morning tiredness		**Very well rested**	**Rested**	**Tired**	**Very tired**	
	1410	184 (13.0%)	718 (50.9%)	458 (32.5%)	50 (3.5%)	
Daytime tiredness		**Not at all**	**Often**	**Always**	**Cannot say**	
	1404	762 (54.3%)	305 (26.0%)	60 (4.2%)	277 (19.7%)	

Table 4 Delivery and newborn outcomes

	n	% or Mean (SD)	Range
Delivery type	1410		
Spontaneous vaginal	1162	82.4%	
Vacuum	106	7.5%	
Elective caesarean	41	2.9%	
Acute caesarean	101	7.2%	
Pain relief in delivery			
Nothing	184	13.0%	
Nitroux oxide	82	5.8%	
Pudendal or paracervical block	255	18.1%	
Epidural/spinal analgesia	890	63.1%	
Duration of delivery			
Duration phase I (min)	1407	480 (350)	0-2315
Duration phase II (min)	1268	21 (19)	1-114
Total duration (min)	1407	511 (362)	0-2357
Oxytocin use	1411		
Yes	811	57.5%	
Gestational age	1414	40.1 (1.2)	33.0-42.7
Birth weight (gram)	1414	3597 (449)	1950-5780
Birth weight Z-score	1414	-0.1 (0.9)	-2.8-6.4
Birth length (cm)	1414	50.5 (1.9)	42.0-58.0
Birth length Z-score	1414	-0.0 (1.0)	-3.9-4.9
Head circumference (cm)	1412	35.0 (1.4)	30.5-40.0
Head circumference Z-score	1412	-0.0 (1.0)	-3.0-3.6
Apgar scores			
1 minutes	1403	8.5	1-10
5 minutes	1401	8.9	3-10
Newborn pH			
Artery	1398	7.3	6.8-7.6

Vein	203	7.3	7.0-7.5

Table 5 Associations between maternal sleep quality and mood symptoms and gestation age and birth weight

Predictor variable	Gestation age (weeks)		Birth weight (grams)		Standardized birth weight	
	Adjusted β (SE)	*p-value*	Adjusted β (SE)	*p-value*	Adjusted β (SE)	*p-value*
Insomnia score	**-0.06 (0.30)**	**0.047**	**-28.30 (10.94)**	**0.010**	-0.04 (0.02)	0.065
General sleep quality	-0.11 (0.08)	0.176	**-62.15 (27.70)**	**0.0025**	-0.10 (0.06)	0.076
Sleep duration (h)	0.05 (0.03)	0.137	**28.06 (12.00)**	**0.019**	0.05 (0.02)	0.053
Sleep need (h)	**0.07 (0.04)**	**0.047**	**27.61 (12.53)**	**0.028**	0.04 (0.03)	0.126
Sleep loss (h)	0.01 (0.03)	0.767	-2.70 (11.76)	0.818	-0.01 (0.02)	0.656
Snoring	0.10 (0.12)	0.391	71.79 (43.26)	0.097	0.13 (0.09)	0.149
Sleepiness score (ESS)	-0.02 (0.01)	0.169	0.13 (4.59)	0.978	0.00 (0.01)	0.758
Depression score (CES-D)	-0.01 (0.01)	0.565	-0.69 (3.59)	0.847	0.00 (0.01)	0.784
Anxiety score (STAI)	-0.01 (0.01)	0.627	-4.09 (5.22)	0.434	-0.01 (0.01)	0.524

All models are adjusted for age, parity, BMI, general health, smoking and education. All variables are considered as a continuous variables except for snoring which was considered as categorical (no vs. yes).

β adjusted regression coefficient, *SE* standard error, *CES-D* Center for Epidemiologic Studies Depression Scale, *ESS* Epworth sleepiness scale, *STAI* State-Trait Anxiety inventory.

Table 6 Associations between maternal sleep quality and mood symptoms and duration of delivery in women with vaginal delivery.

	I phase[2]		II phase[2]		Total duration[2]	
Explanatory variable	Adjusted[1] β (SE)	*p-value*	Adjusted[1] β (SE)	*p-value*	Adjusted[1] β (SE)	*p-value*
Insomnia score	-0.001 (0.07)	0.905	0.003 (0.01)	0.759	0.00 (0.006)	0.959
Snoring	**-0.07 (0.03)**	**0.010**	-0.057 (0,043)	0.181	**-0.063 (0.026)**	**0.015**
Sleep duration (h)	-0.011 (0.01)	0.124	0.011 (0.012)	0.360	-0.010 (0.007)	0.151
Sleep need (h)	0.010 (0.01)	0.213	0.004 (0.012)	0.749	0.010 (0.007)	0.199
Sleep loss (h)	**0.019 (0.01)**	**0.001**	-0.007 (0.001)	0.525	**0.017 (0.007)**	**0.012**
Sleepiness score (ESS)	0.001 (0.003)	0.654	-0.002 (0.004)	0.670	0.001 (0.003)	0.709
Depression score (CES-D)	0.001 (0.002)	0.815	0.001 (0.003)	0.865	0.00 (0.002)	0.823
Anxiety score (STAI)	-0.001 (0.003)	0.778	0.004 (0.005)	0.433	-0.001 (0.003)	0.787

[1] All models are adjusted for age, parity, BMI, general health, smoking and education. Models are performed only in women with vaginal delivery (spontaneous+vacuum assisted, *n* = 1268).

[2] All outcome variables were log transformed before analyses.

All variables are considered as continuous variables except for snoring which was considered as categorical (no vs. yes) .

β adjusted regression coefficient, *SE* standard error, *CES-D* Center for Epidemiologic Studies Depression Scale, *ESS* Epworth sleepiness scale, *STAI* State-Trait Anxiety inventory.

Table 7 Odds rations for oxytocin use in women with vaginal delivery (*n* = 1268) and risk for elective cesarean section in all women (*n* = 1410)

	Oxytocin use		Elective Caesarean Section	
Explanatory variable	Adjusted OR (95% CI)	*p-value*	Adjusted OR (95% CI)	*p-value*
Insomnia score < vs. ≥ 4	**1.54 (1.00-2.38)**	**0.049**	0.84 (0.29-2.44)	0.743
Snoring (no vs. yes)	1.01 (0.64-1.60)	0.969	2.17 (0.03-4.40)	0.074
Sleep duration (< 6 hours)	1.27 (0.65-2.49)	0.481	1.66 (0.47-5.81)	0.430
Sleep loss (> 2 hours)	0.86 (0.53-1.41)	0.553	1.46 (0.49-4.33)	0.497
Sleepiness score (ESS) (< vs. ≥ 11)	1.27 (0.72-2.26)	0.412	1.03 (0.24-4.48)	0.974
Depression score (CES-D) (< vs. ≥ 12)	**1.76 (1.02-3.04)**	**0.044**	**4.67 (2.04-10.68)**	**<0.001**
Anxiety score (STAI) (< vs. ≥ 12)	**1.91 (1.28-2.84)**	**0.001**	**2.22 (1.03-4.79)**	**0.042**

[1] All models are adjusted for age, parity, BMI, general health, smoking and education. All explanatory variables are considered as a categorical variables.

OR adjusted odds ratio, *CI* confidence interval, *CES-D* Center for Epidemiologic Studies Depression Scale, *ESS* Epworth sleepiness scale, *STAI* State-Trait Anxiety inventory.

Figures

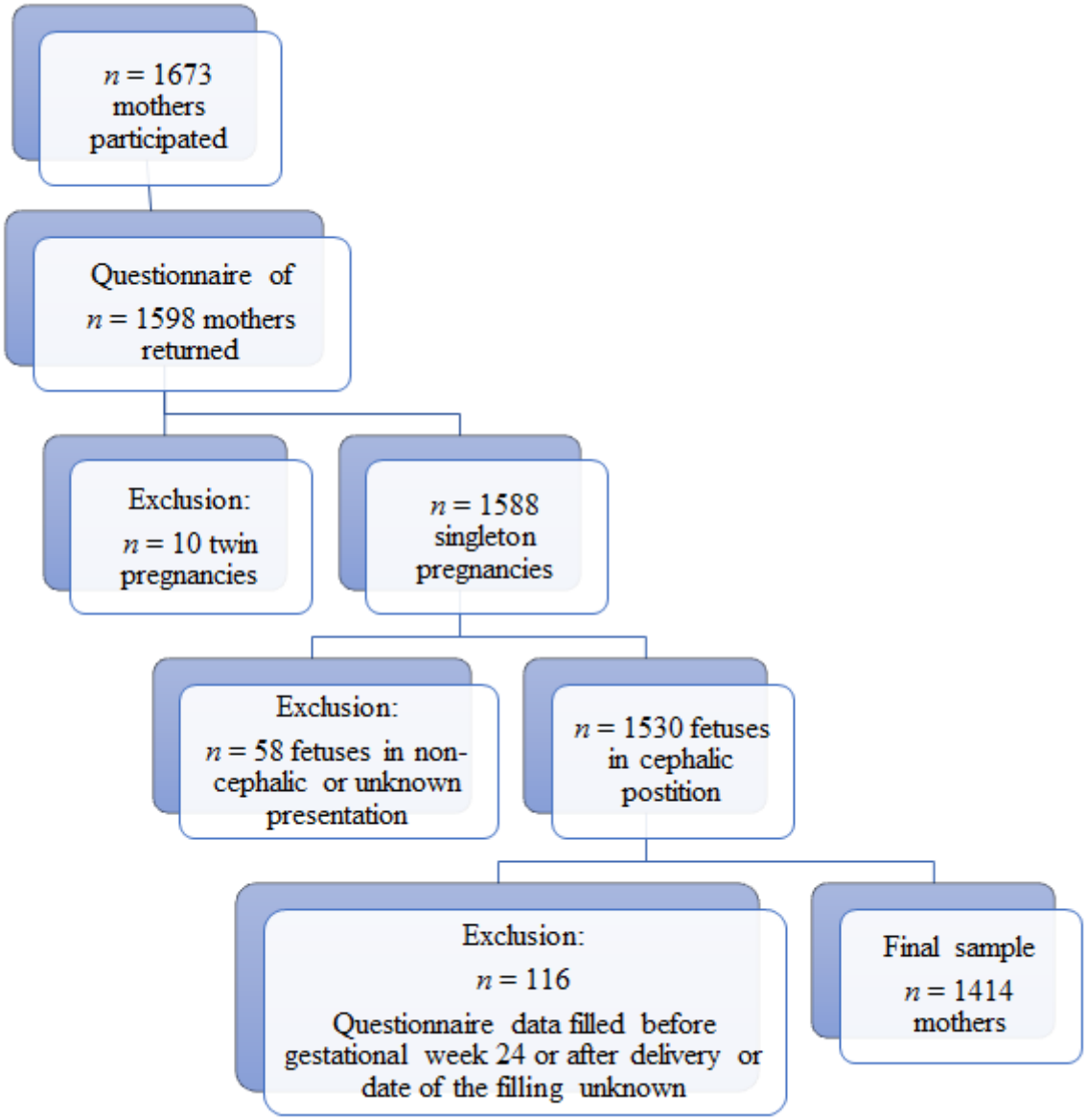

Figure 1

Flowchart of the study design