

Sleep Quality and BMI in Pregnancy– A Prospective Cohort Study

Yafang Tang

KK Women's and Children's Hospital

Fei Dai

KK Women's and Children's Hospital

Nurul Syaza Razali

KK Women's and Children's Hospital

Shephali Tagore

KK Women's and Children's Hospital

Bernard SM Chern

KK Women's and Children's Hospital

Kok Hian Tan (✉ tan.kok.hian@singhealth.com.sg)

KK Women's and Children's Hospital

Research Article

Keywords: Sleep, BMI, pregnancy

Posted Date: October 5th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-924730/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: Pregnancy associated sleep disturbance is a common pregnancy-related complication which can lead to significant maternal distress and adverse pregnancy outcomes. Sleep quality can be affected by multiple factors and high BMI or obesity has been recognized as one of them. Various previous studies have demonstrated poorer sleep quality during pregnancy. However, most studies included assessment at only one point of pregnancy. This prospective cohort study aimed to better evaluate the effect of pregnancy on the quality of sleep throughout the antenatal period and how BMI affects antenatal sleep.

Methods: A total of 926 women were recruited before 14 weeks of gestation and followed throughout pregnancy. The Pittsburgh Sleep Quality Index questionnaire was employed to assess sleep quality in 4 antenatal visits throughout pregnancy. Their weight was also recorded at each visit.

Results: The PSQI global score was higher towards the later part of pregnancy (6.4 to 8.0, $p < 0.001$) and highest at the 4th visit. Sleep latency was longer as pregnancy progressed (18.5 mins to 23.2 mins, $p = 0.001$). Sleep duration became shorter over time and was the shortest at the 4th visit (7.1 hours to 6.5 hours, $p < 0.001$). Sleep efficiency was the lowest at the 4th visit (85.2% to 81.6%, $p < 0.001$). The same trend was observed for subjects in different BMI groups throughout pregnancy. PSQI score increased and sleep duration decreased as BMI increased. The effect of increasing BMI on PSQI and sleep duration was only observed in the higher BMI groups ($> 25 \text{ kg/m}^2$).

Conclusions: Our study showed that sleep quality gradually declined throughout pregnancy for all BMI groups. Higher BMI was associated with poorer sleep as represented by PSQI score and sleep duration, particularly in the high BMI subgroups.

Background

Sleep disturbance has long been recognized as one of the common obstetric complications^{1,2}. Previous studies have shown sleep disturbances in all trimester throughout pregnancy^{3,4}. Shorter sleep duration, poorer sleep efficiency, insomnia and overall poor sleep quality characterize the sleep of antenatal women, especially in late pregnancy⁵⁻⁷. A review by Chang et al reported mean sleep duration of 6.8 to 7.8 hours per night before pregnancy, slightly increasing during the 1st trimester, then decreasing during the 2nd and 3rd trimesters⁸. Risk factors for poor sleep in pregnancy include poor pre-pregnancy sleep, maternal emotional disturbances (depression, anxiety, stress), body image, obesity, more weight gain during pregnancy, physiological changes during pregnancy such as decreased tone of esophageal sphincter, hormonal changes, increased uterine size and increased micturition⁹⁻¹³. Poor sleep during pregnancy can cause adverse health concerns for the pregnant women^{14,15} and can lead to potential adverse outcomes of pregnancy such as intrauterine growth restriction and preterm birth¹⁶⁻¹⁸.

Most previous studies have focused on one point of time in pregnancy or were cross sectional studies involving multiple stages of pregnancy. A prospective study by Plancoulaine et al, one of the few cohort studies, showed gradual decline in sleep duration as pregnancy progresses¹⁹. Our prospective study aimed to assess the change of sleep quality in detail (overall sleep quality, sleep duration, sleep efficiency and sleep latency) as pregnancy progresses. Subjects were followed from the first antenatal visit throughout the entire pregnancy, and sleep quality was assessed thoroughly at 4 visits. As obesity is increasingly prevalent globally and associated with sleep disorders such as sleep apnea and cause sleep disturbances in both non-pregnant and pregnant population²⁰, it is interesting to explore sleep quality in women in different body mass index (BMI) groups. One large cohort study involving 2366 pregnant women by Guinhouya BC et al showed overall sleep quality was worst in 3rd trimester and obese women exhibit a greater PSQI score than women with normal weight²¹. However, large scale prospective cohort studies are scarce. Our study also aimed to provide a comprehensive comparison on various aspects of sleep through pregnancy among women in different BMI categories.

Methods

The present study was part of the Neonatal and Obstetric Risk Assessment (NORA) study, a large prospective cohort study. Women with singleton pregnancies attending their first prenatal visit at KK Women's and Children's Hospital, Singapore, between September 1, 2010, and August 31, 2014, were invited to participate. All women with viable singleton pregnancies (confirmed by ultrasonography) and at less than 14 weeks of gestation were potentially eligible. Patients with chronic medical conditions such as renal disease and systemic lupus erythematosus, pregnancies complicated by aneuploidy or fetal anomalies, and pregnancies ending in termination, spontaneous abortion, or fetal death before 24 weeks of gestation were excluded. Pregnancy duration was determined from the menstrual history and was confirmed by fetal crown-rump length at the first prenatal ultrasonography examination. Enrolment details were described elsewhere²². Briefly, of the 3271 women identified, 1013 women consented to the study and 934 women completed all follow up visits (92%). 926 women had complete delivery record (96%). At recruitment, a detailed interview, a dating ultrasound scan and routine antenatal blood collection were done. At subsequent follow up visits, clinical and laboratory data were collected at 18 to 22 weeks, 28 to 32 weeks and 34 weeks and above. Following delivery, detailed information on pregnancy complications, labor, delivery and neonatal outcomes was collected. The present study mainly focused on patient demographics, sleep quality throughout pregnancy and BMI.

Information on socio-demographic and life style characteristic was collected during the 1st antenatal visit and updated during each subsequent visit when applicable. Included were age, BMI, race, parity, marital status, education level, occupation and monthly income. For assessment of effect of BMI on sleep quality, subjects were grouped into underweight (<18.5kg/m²), healthy weight (18.5 - <25 kg/m²), overweight (25 - < 30 kg/m²) and obese (30 kg/m² and above) based on the BMI in the first visit.

Four study visits at the different gestational ages of pregnancy were conducted in the NORA Study (1st visit at 11-14 weeks, 2nd visit at 18-22 weeks, 3rd visit at 28-32 weeks and 4th visit after 34 weeks of gestation). During each visit, sleep quality was assessed via the Pittsburgh Sleep Quality Index (PSQI), which is a widely used and well-validated 19-item self-report questionnaire that measures sleep quality in adults²³. It provides a global score ranging from no sleep difficulty to severe difficulties. Higher PSQI score indicates poorer sleep. Four main questions were asked in the questionnaire: (1) "During the past month, what time have you usually gone to bed at night"; (2) How long (in minutes) has it usually taken you to fall asleep each night"; (3) What time have you usually got up in the morning"; (4) How many hours of actual sleep did you get at night, which may be different from the number of hours you spent in bed". Sleep duration is defined as question 4. Sleep latency is defined as question 2. Sleep efficiency is defined as sleep duration / hours in bed. Questions on whether there is difficulty in falling asleep, night awakening, bathroom use at night were also included in the questionnaire. PSQI score was calculated after adding the scores for each question.

Maternal demographics such as age and BMI were considered as continuous variables and were described as mean \pm standard deviation. Other factors including race, education, marital status, occupation, income and parity were considered as categorical variables and were described as the sample number and frequency of each category. The mean PSQI, latency, duration and efficiency of sleep for each visit were described as mean \pm standard deviation. Mixed model analysis was employed to study the change of sleep quality at different stages of pregnancy. Analysis was adjusted for age, race, education, coffee drinking, Smoking, exercise, SBP and parity. Repeated Covariance type of Mixed model analysis was Scaled Identity. Statistical analysis of the data was performed using SPSS 22.0 (IBM, Armonk, NY, USA).

Results

The basic demographics of the study subjects were shown in Table 1. The average age of the study population was 30 years with an average BMI of 24.2kg/m² at the first visit. Majority of the subjects were of Chinese ethnicity (50.8%), followed by Malay which made up of 20.7% of the subjects. The remaining subjects were either Indians (10.8%) or others

(11.4%). Most of the subjects have education levels of high school/junior college and above (98.4%). Their household income ranges from <3,500 (34.4%) to more than 8,500 Singapore dollars a month, with most women working as white-collar workers (79.9%). Nulliparous women made up of 54.4% of the study subjects. 21% of women continued to drink coffee during pregnancy while only a small percentage of women continued to smoke (2.6%) or drink alcohol (1.2%). Only 8.4% women remained active in pregnancy and continued to exercise. Lastly, the average blood pressure at first visit was 108.6/65.8 mmHg.

Table 1
Maternal socio-demographics, life styles and blood pressure at first visit (11-14 weeks).

Maternal Characteristics	N=926	mean±SD / %
Age (years)	926	30.6±5.0
BMI (kg/m ²) (first visit)	921	24.2±4.7
Race		
Chinese	470	50.8
Indian	100	10.8
Malay	250	27.0
Other	106	11.4
Missing	0	0
Education		
Secondary school or under	12	1.3
High school	209	22.6
Junior college	367	39.6
University or above	335	36.2
Missing	3	0.3
Marital status		
Married	871	94.1
Single/Divorced/Widowed	55	5.9
Missing	0	0
Occupation		
White-collar worker	740	79.9
Blue-collar worker	176	19.0
Unemployment	10	1.1
Missing	0	0
Total monthly household income (S\$)		
< 3500	319	34.4
3500-5500	280	30.2
5501-8500	203	21.9
>8500	122	13.2
Missing	2	0.2
Coffee drinking (yes, %)	194	21.0

Continuous variables are expressed in mean±SD while categorical variables are expressed as %

Maternal Characteristics	N=926	mean±SD / %
Smoking (yes, %)	24	2.6
Drinking alcohol (yes, %)	11	1.2
Exercise (yes, %)	78	8.4
SBP(mmHg)	922	108.6±11.3
DBP(mmHg)	922	65.8±8.3
Parity		
0 previous birth	498	54.4
1+ previous birth	418	45.6
Missing	0	0
Continuous variables are expressed in mean±SD while categorical variables are expressed as %		

The change in sleep quality as pregnancy progresses was shown in Table 2. Sleep efficiency was the highest during the 1st visit (85.2%) and lowest at the 4th visit (81.6%) ($p<0.001$). PSQI score gradually increased during pregnancy and was the highest at the 4th visit (8 vs 6.4 at the 1st visit, $p<0.001$). Sleep latency was also longer when pregnancy was more advanced with the longest latency of 23.2 mins at the 4th visit compared to 18.5 mins at the 1st visit ($p<0.001$). Sleep duration gradually shortened as pregnancy progresses, from 7.1 hours during the 1st visit to 6.5 hours during the 4th visit ($p<0.001$).

Table 2
 BMI and sleep quality measurements throughout 4 antenatal visits.

	BMI Group	11-14 weeks		18-22 weeks		28-32 weeks		>34 weeks		F	P	
		N	Mean	SD	Mean	SD	Mean	SD	Mean			SD
BMI (kg/m²)		780	24.0	4.7	25.2	4.5	27.1	4.5	28.2	4.8	1914.5	<0.001*
	<18.5	61	17.3	1.0	18.8	1.2	20.8	1.5	21.9	1.8	13.2	<0.001*
	18.5-24.9	443	21.8	1.7	23.0	1.8	25.1	2.1	26.3	3.1	1049.3	<0.001*
	25-29.9	192	27.3	1.5	28.3	1.7	30.0	2.0	31.1	2.2	294.6	<0.001*
	≥30	84	33.4	3.3	34.0	3.1	35.5	3.5	36.6	4.1	185.2	<0.001*
Sleep efficiency (%)		758	85.2	14.3	85.1	14.8	83.3	15.0	81.6	16.5	8.8	<0.001*
	<18.5	59	83.7	15.2	83.4	15.3	82.6	16.9	80.9	19.1	1.9	0.137
	18.5-24.9	431	84.9	13.6	85.1	14.9	83.3	14.5	82.3	15.8	3.6	0.013*
	25-29.9	186	84.9	15.4	85.2	14.3	82.6	15.7	80.6	17.5	0.5	0.679
	≥30	82	88.3	14.5	86.2	15.5	85.0	14.6	80.8	16.0	6.8	<0.001*
PSQI Score		749	6.4	3.0	6.2	3.1	7.1	3.3	8.0	3.3	74.1	<0.001*
	<18.5	58	6.3	2.9	6.2	3.5	6.6	3.3	7.9	3.3	3.4	0.026*
	18.5-24.9	428	6.5	3.1	6.2	3.0	7.1	3.4	7.9	3.2	20.7	<0.001*
	25-29.9	182	6.4	3.0	6.0	3.4	7.0	3.2	8.0	3.3	20.6	<0.001*
	≥30	81	6.5	3.2	6.5	3.2	7.6	3.1	8.4	3.4	18.5	<0.001*
Sleep latency (mins)		747	18.5	17.0	18.4	16.8	21.0	19.0	23.2	20.4	12.0	<0.001*
	<18.5	58	18.4	18.0	17.4	18.7	20.4	18.3	20.4	17.2	3.0	0.041*
	18.5-24.9	429	18.1	15.8	18.1	16.0	21.0	19.6	22.8	19.7	4.1	0.006*
	25-29.9	179	17.0	14.3	17.3	16.2	19.9	18.0	22.1	17.4	4.5	0.004*
	≥30	81	24.2	25.0	22.9	20.0	24.0	18.0	29.4	29.3	1.2	0.324
Sleep duration (hours)		760	7.1	1.5	7.0	1.5	6.6	1.5	6.5	1.7	23.0	<0.001*
	<18.5	60	7.3	1.6	6.9	1.5	6.9	1.7	6.5	1.8	0.1	0.971
	18.5-24.9	432	7.0	1.5	7.0	1.5	6.6	1.5	6.5	1.7	9.0	<0.001*

BMI Group	11-14 weeks		18-22 weeks		28-32 weeks		>34 weeks		F	P	
	N	Mean	SD	Mean	SD	Mean	SD	Mean			SD
25-29.9	186	7.1	1.6	7.0	1.6	6.6	1.5	6.5	1.8	3.0	0.03*
≥30	82	7.1	1.8	7.0	1.5	6.6	1.6	6.4	1.6	5.3	0.001*

Repeated Covariance type: Scaled Identity

Adjusted by: age, race, education, coffee drinking, Smoking, exercise, SBP and parity

BMI gradually increased as pregnancy progressed as expected, from 24kg/m² in the first visit to 28.2kg/m² in the 4th visit (Table 2). At the first visit, majority of subjects were under the normal BMI range (443/780, 56.8%) with a significant percentage overweight (192/780, 24.6%) or obese (84/780, 10.8%). Sleep quality change in the 4 different BMI groups generally follow the same trend as that of the whole study population, with worsening sleep efficiency, higher PSQI scores, longer sleep latency and shorter sleep duration as pregnancy progressed (Table 2). Difference for some of the subgroups did not achieve statistical significance such as PSQI score for the BMI < 18.5kg/m² group. It can partly be explained by type II error due to the small sample size (58) in that group.

Correlation between BMI and sleep throughout pregnancy was then explored further using mixed model analysis. Table 3 showed that PSQI score was higher with increasing BMI (p = 0.03) while sleep duration was shorter with increasing BMI (p = 0.08). Upon closer scrutiny, the subgroups with higher BMI (BMI 25-29.9kg/m² and ≥30kg/m²) seemed to be the ones with their sleep quality significantly affected by increasing BMI. In the group of subjects with BMI between 25-29.9kg/m², sleep duration was significantly shorter when BMI increased (P = 0.005). For the subjects with BMI ≥30 kg/m², PSQI score was significantly higher with increasing BMI (p=0.015) and sleep duration was shorter (p=0.056).

Table 3
Mixed model analysis of the correlation between BMI and sleep (log) throughout 4 antenatal visits

BMI (kg/m ²)	Efficiency		PSQI Score		Latency		Duration	
	β	P	β	P	β	P	β	P
<18.5	-0.007	0.598	-0.019	0.472	0.072	0.088	-0.019	0.216
18.5-24.9	0.002	0.322	0.004	0.352	-0.002	0.785	0.000	0.944
25-29.9	-0.002	0.321	0.004	0.338	0.007	0.358	-0.007	0.005*
≥30	-0.001	0.382	0.007	0.015*	0.004	0.497	-0.003	0.056*
total	0.000	0.595	0.003	0.030*	0.003	0.149	-0.001	0.080*

Repeated Covariance type: Scaled Identity

Adjusted by: age, race, education, coffee drinking, Smoking, exercise, SBP and parity

Discussion

Our study showed that sleep quality progressively worsens as pregnancy advances, with higher PSQI score, longer latency, shorter duration and poorer efficiency. Women in different BMI groups generally followed a similar trend while the correlation between higher BMI and worse sleep quality was more pronounced in the overweight and obese groups.

Sleep disturbances are widely recognized throughout pregnancy with more previous studies reporting sleep disturbances in later trimesters. A cohort study by Plancoulaine et al. showed that sleep duration decreased from 8.0 hours in first trimester to 7.2 hours in third trimester. However, overall sleep quality and other aspects of sleep including sleep latency and efficiency were not assessed in that study. Another small cohort study published recently showed that sleep duration (8.1 in first trimester and 7.5 in third trimester) was not significantly different throughout pregnancy²⁴. However, that study consisted of 176 women only and the non-significant result could be due to type II error. Guinhouya et al's cohort study demonstrated best sleep quality in 2nd trimester and no significant difference in sleep duration throughout 3 trimesters²¹. Our study which studied comprehensively, overall sleep quality, sleep duration, sleep efficiency and sleep latency, showed that sleep disturbances are most severe in the last antenatal visit, consistent with most previous studies. The reason for the progression of sleep disturbances may partially be explained by the different mechanisms contributing to poor sleep in different stages of pregnancy. In the first trimester, potential contributing factors include urinary frequency, heartburn, hyperemesis^{25,26}. As pregnancy progresses to the second trimester, the effect of estrogen and progesterone may cause tissue edema and result in obstructive sleep apnea²⁷. In the last trimester, the gravid uterus, urinary frequency, abdominal and back pain, gastroesophageal reflux play important roles in the worsening of sleep quality^{28,29}. Meanwhile, pre-pregnancy sleep disorders, mood disorders and emotional stress should not be underestimated¹⁰.

Obesity has been recognized as a risk factors for poor sleep quality antenatally³⁰. In a large-scale prospective study (n=2366), Guinhouya et al showed that pre-pregnancy high BMI correlates with poorer overall PSQI score²¹. Another study by Vézina-Im et al showed no difference in sleep duration among women in different BMI groups³¹. Our study employed mixed model analysis and showed that overall PSQI score was poorer and sleep duration was shorter with increasing BMI. This correlation was mainly contributed by the overweight and obese groups. Obesity can potentially affect sleep by increasing risk of sleep apnea and other sleep disorders. Possible mechanisms include increased fat deposition around the upper airway causing obstruction of breathing and reducing the flow of oxygen³². Maintaining healthy body weight and BMI may potentially improve sleep in pregnant women.

Our study did not include the preconception and postpartum phase for comparison of sleep quality. Future studies may consider including pre-pregnancy and postnatal sleep quality as it would better demonstrate the natural progression of sleep disturbances during pregnancy and postpartum period. Sleep quality was assessed purely with questionnaires which was limited by potential subjective bias / recall error. Objective assessment of sleep quality such as polysomnography can be considered in future studies although it may not be cost effective. Our study is an observational study without any intervention on sleep being investigated. Interventions to improve sleep could be explored in future and offered to pregnant women with sleep disturbances to achieve the best maternal and fetal outcome. One interesting study reported significant improvement in sleep in terms of longer sleep duration and less sleep disruption with home-based cognitive-behavioral training (CBT) program during late pregnancy³³. CBT was also explored in a study in obese women which showed improvement in insomnia symptoms³⁴. A recently published systematic review which included studies on CBT, pharmacotherapy, acupuncture, mindfulness and herbal remedies, emphasized however that there is still lack of evidence for preventive and treatment options for sleep problems in pregnancy³⁵. Future studies are still needed due to the paucity of data.

Conclusion

In conclusion, this study is the first large prospective cohort study that evaluated detailed sleep quality throughout pregnancy. We showed that sleep disturbances progressively worsen with the advancement of pregnancy. Obesity is a potential factor that is associated with poorer sleep during pregnancy, particularly for the overweight and obese women. As good quality of sleep is associated with maternal well-being and good fetal outcome, it is important to advise pre-conception or antenatal patients to adopt healthy life style, maintain normal BMI and recognize sleep disturbances throughout the antenatal period and intervene appropriately to prevent adverse outcomes.

Abbreviations

NORA: Neonatal and obstetric risk assessment

PSQI: Pittsburgh Sleep Quality Index

BMI: body mass index

CBT: cognitive-behavioral training

Declarations

Ethics approval and consent to participate:

The study was approved by the SingHealth Centralised Institutional Review Board Ethics Committee, Singapore (CIRB Ref No. 2010/214/D). All methods were performed in accordance with the relevant guidelines and regulations. A written informed consent was obtained from all participants.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and/or analysed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity, but are available from the corresponding author on reasonable request.

Competing interest:

The authors declare that they have no competing interests.

Funding:

This study is supported by Singapore National Medical Research Council (NMRC) Collaborative Centre Grant grant—Integrated Platform for Research in Advancing Metabolic Health Outcomes of Women and Children, IPRAMHO/CGAug16C008) and Neonatal and Obstetrics Risks Assessment (NORA) prospective cohort study (Project Grant number NMRC/PPG/KKH/2010).

Author's contribution:

YT contributed to the design of the study, data analysis and interpretation, manuscript drafting and review.

FD contributed to the design of the study, data analysis, data interpretation and review of manuscript to be published.

NSR, ST and BC contributed to the conception and design of the study and review of manuscript to be published.

KHT contributed to the conception and design of the study, review of data analysis and review of manuscript to be published.

Acknowledgements:

The authors thank all the members involved in Integrated Platform for Research in Advancing Metabolic Health Outcomes in Women and Children (IPRAMHO) and NORA study for their invaluable contribution.

References

1. Mindell JA, Jacobson BJ. Sleep disturbances during pregnancy. *J Obstet Gynecol Neonatal Nurs* 2000;29:590–597.
2. Pien GW, Schwab RJ. Sleep disorders during pregnancy. *Sleep*. 2004;27:1405–1417.
3. Santiago JR, Nolleto MS, Kinzler W, Santiago TV. Sleep and sleep disorders in pregnancy. *Ann Intern Med* 2001;134:396–408.
4. Sahota PK, Jain SS, Dhand R. Sleep disorders in pregnancy. *Curr Opin Pulm Med*. 2003;9:477–483.
5. Hutchison BL, Stone PR, McCowan LM, Stewart AW, Thompson JM, Mitchell EA. A postal survey of maternal sleep in late pregnancy. *BMC Pregn Childbirth*. 2012;12:144.
6. Hertz G, Fast A, Feinsilver SH, Albertario CL, Schulman H, Fein AM. Sleep in normal late pregnancy. *Sleep*. 1992;15:246–51.
7. Greenwood KM, Hazendonk KM. Self-reported sleep during the third trimester of pregnancy. *Behav Sleep Med*. 2004; 2:191–204.
8. Chang, J. J., Pien, G. W., Duntley, S. P., & Macones, G. A. Sleep deprivation during pregnancy and maternal and fetal outcomes: Is there a relationship? *Sleep Medicine Reviews*. 2010; 14: 107–114.
9. Goyal, D., Gay, C. L., & Lee, K. A. Patterns of sleep disruption and depressive symptoms in new mothers. *Journal of Perinatal & Neonatal Nursing*. 2007; 21:123–129.
10. Hung HM, Tsai PS, Ko SH & Chen CH. Patterns and predictors of sleep quality in Taiwanese pregnant women. *Am J Matern Child Nurs*. 2013; 38:95–101.
11. Haney A, Buysse D.J, Okun M. Sleep and pregnancy-induced hypertension: A possible target for intervention? *J Clin Sleep Med*. 2013; 9:1349–1356.
12. Saaresranta T, Polo O. Hormones and breathing. *Chest*. 2002;122:2165–2182.
13. Feinsilver SH, Hertz G. Respiration during sleep in pregnancy. *Clin Chest Med*. 1992;13:637–464.
14. Izci-Balserak B, Pien GW. Sleep-disordered breathing and pregnancy: potential mechanisms and evidence for maternal and fetal morbidity. *Curr Opin Pulm Med*. 2010;16:574–852.
15. O’Keeffe M, St-Onge MP. Sleep duration and disorders in pregnancy: implications for glucose metabolism and pregnancy outcomes. *Int J Obes*. 2013;37:765–770.
16. Okun ML, Roberts JM, Marsland AL, Hall M. How disturbed sleep may be a risk factor for adverse pregnancy outcomes. *Obstet Gynecol Surv*. 2009;64:273–280.
17. O’Brien LM. Sleep disruption and adverse pregnancy outcomes. *BMC Pregn Childbirth*. 2012;12:11.
18. August EM, Salihu HM, Biroscak BJ, Rahman S, Bruder K, Whiteman VE. Systematic review on sleep disorders and obstetric outcomes: scope of current knowledge. *Am J Perinatol*. 2012;30:323–34.
19. Plancoulaine S, Flori S, Bat-Pitault F, Patural H, Lin JS, Franco P, Sleep Trajectories Among Pregnant Women and the Impact on Outcomes: A Population-Based Cohort Study. *Matern Child Health J*. 2017;21:1139–1146.
20. Beccuti G, Pannain S. Sleep and Obesity. *Curr Opin Clin Nutr Metab Care*. 2011; 14:402–412.
21. Guinhouya BC, Bisson M, Dubois L, Series F, Kimoff JR, Frase WD, Marc I. Body Weight Status and Sleep Disturbances During Pregnancy: Does Adherence to Gestational Weight Gain Guidelines Matter? *J Women’s health*. 2019; 28: 535–543. DOI: 10.1089/jwh.2017.6892

22. Ng QJ, Zhang J, Dai F, Ng MJ, Razali NS, Win NM, et al. Neonatal and obstetric risk assessment (NORA) pregnancy cohort study in Singapore. *Int J Gynecol Obstet Res* 2018; 4:31–7
23. Buysse D.J., Reynolds C.F., Monk T.H., Berman S.R., Kupfer D.J. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989; 28:193–213.
24. Franco-Sena AB, Kahn LG, Farias DR, Ferreira AA, Eshriqui I, Figueiredo ACC, Litvak P, Schlüssel MM, Kac G. Sleep duration of 24 h is associated with birth weight in nulli- but not multiparous women. *Nutrition.* 2018; 55-56:91–98.
25. Facco, F. L., Kramer, J., Ho, K. H., Zee, P. C., & Grobman, W. A. (2010). Sleep disturbances in pregnancy. *Obstetrics & Gynecology.* 2010; 115: 77-83.
26. Ross, L. E., Murray, B. J., & Steiner, M. Sleep and perinatal mood disorders. A critical review. *Journal Psychiatry Neuroscience.* 2015; 30:247–256. PMID: 16049568
27. Leung, P. L., Hui, D. S. C., Leung, T. N., Yueng, P. M., & Lau, T. K. Sleep disturbances in Chinese pregnant women. *International Journal of Obstetrics and Gynecology.* 2005;112: 1568–1571.
28. Harano, S., Ohida, T., Kaneita, Y., Yokoyama, E., Tamaki, T., Takemura, S., Hayashi, K. Prevalence of restless legs syndrome with pregnancy and the relationship with sleep disorders in the Japanese large population. *Sleep & Biological Rhythms.* 2008; 6:102–109.
29. Sloan, E. P. Sleep disruption during pregnancy. *Sleep Medicine Clinics.* 2008; 3:73–80.
30. Rice JR, Larrabure-Torrealva GT, Luque Fernandez MA, et al. High risk for obstructive sleep apnea and other sleep disorders among overweight and obese pregnant women. *BMC Pregnancy Childbirth* 2015;15:198
31. Vézina-Im LA, Lebel A, Gagnon P, Nicklas TA, Baranowski T. **Association between sleep and overweight/obesity women among women of childbearing age in Canada.** *Can J Public Health.* 2018;**109:516.**
32. Venkata C, Venkateshiah SB. Sleep-disordered breathing during pregnancy. *J Am Board Fam Med.* 2009;22:158–68.
33. Lee KA, Gay CL, Alsten CR. Sleep Enhancement Training for Pregnant Women. *Obstet Gynecol,* 2016;128:964–971.
34. Cain MA, Brumley J, Louis-Jacques A, et al. A pilot study of a sleep intervention delivered through group prenatal care to overweight and obese women. *Behav Sleep Med.* 2020;18:477–487.
35. Bacaro V, Benz F, Pappacogli A, et al. Interventions for sleep problems during pregnancy: a systematic review. *Sleep Med Rev.* 2020;50:101234.