ORIGINAL ARTICLE

Prevalence of Snoring in Pregnancy and Its Maternal-Fetal Outcomes at Vajira Hospital

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Background: Snoring is an important symptom that is associated with obstructive sleep apnea and increases the risk of adverse pregnancy outcomes. In Thailand, the prevalence of snoring during pregnancy is uncertain. Determining the prevalence and characteristics may reduce the prevalence of snoring and improve pregnancy outcomes.

Objective: The primary outcome was to determine the prevalence of snoring in Thai pregnant women in the third trimester, including pregnancy and chronic onset. The secondary outcome was to investigate the associations between pregnancy outcome and habitual snorer or those identified as high risk by the Thai Berlin Questionnaire.

Materials and Methods: Three hundred eighty-two singleton pregnant women aged at least 18 years and at least 33 weeks of gestational age were recruited from the antenatal care clinic at Vajira Hospital, Navamindradhiraj University, between November 2021 and September 2022 and filled out the Thai Berlin Questionnaire. The 382 pregnant women were identified the presence of snoring or high risk of OSA in the previous month. Medical records, including demographic information and pregnancy outcomes, were collected, and analyzed.

Results: The prevalence of snoring was 31.4% in the third trimester of pregnancy of which 27% were pregnancy onset snoring and 4.4% were chronic onset snoring. Habitual snoring was significantly different from non-snoring in regard to the requirement for positive-pressure ventilation in newborns (aOR 6.67, 95% CI 1.2 to 35.54). The high risk group had significantly more pregnancy induced hypertension than the low risk group (aOR 5.96, 95% CI 2.15 to 16.5), gestational hypertension (aOR 13.6, 95% CI 2.1 to 86.8), preeclampsia (aOR 4.07, 95% CI 1.09 to 15.2), severe preeclampsia (aOR 4.9, 95% CI 1.15 to 20.93), preterm birth (aOR 6.21, 95% CI 1.58 to 24.42), and low birth weight of newborn (aOR 6.09, 95% CI 2.5 to 14.87).

Conclusion: The prevalence of snoring among Thai pregnant women was comparable to previous Western studies. Screening pregnant women at risk of the symptom may provide an early chance to lower the prevalence of snoring and adverse pregnancy outcomes.

Keywords: Snoring; Snoring in pregnancy; Pregnancy outcomes

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Snoring is a noise that is caused by a vibration of the soft tissue in the upper airway, induced by respiration during sleep. Pregnancy leads to a change in the physiological and anatomical upper airway structure, which may increase the risk of sleep disordered breathing (SDB). There is a study showing that snoring occurs more frequently in pregnant women than in non-pregnant, with a prevalence ranging from 14% to 45%[1], as well as increases the risk of adverse pregnancy outcomes such as pregnancy-induced hypertension, gestational hypertension, fetal growth restriction, and preterm delivery[2-4].

Habitual snoring is an important symptom that is associated with obstructive sleep apnea (OSA) and SDB in pregnancy. Even though treatment with continuous positive airway pressure (CPAP) may improve results of hemodynamic parameters and fetal wellbeing despite very mild SDB such as snoring[2], OSA remains highly under-diagnosed and the majority of women with OSA do not realize they have it[5]. Due to limitation, the diagnosis requires a fully attended polysomnography in a laboratory setting, which is a gold standard test for diagnosis[6]. Polysomnography is considered resource-intensive and expensive. It also requires patients to stay overnight for evaluation

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and have to wait for polysomnography several months. For this reason, the Berlin Questionnaire was adopted to identify patients with habitual snoring and high risk for OSA. This screening test is known for its simplicity, good sensibility, and widespread use. The questionnaire consists of ten questions divided into three categories for assessing risk factors of OSA such as snoring behavior, wake time sleepiness, fatigue, presence of hypertension, and obesity. The Thai Berlin Questionnaire had been evaluated for reliability and validity when compared to the original English version[7]. It can further be used as a test for pregnant women who visit an antenatal care clinic. There are only a few studies about the prevalence of snoring in pregnancy in Thailand. In Asian people, the results may differ from previous studies in Western countries due to differences of race, ethnicity, and obesity status[8].

The primary purpose of the present study was to determine prevalence of snoring in Thai pregnant women including pregnancy and chronic onset. The associations between pregnancy outcomes and habitual snorer or those identified as high risk by the Thai Berlin Questionnaire were the secondary outcome[7]. Determining the prevalence and characteristics might reduce the prevalence of snoring and improve pregnancy outcomes.

Materials and Methods

Participants

The inclusion criteria were 1) age 18 years or older, 2) gestational age 33 weeks or more, 3) singleton pregnancy, 4) having a bed partner. Three hundred eighty-five pregnant women were recruited by the research assistant trainee from the antenatal care clinic at the Faculty of Medicine Vajira Hospital, Navamindradhiraj University, between November 2021 and September 2022. The pregnant women who decline to participate or unable to understand the questionnaire or provided incomplete data were excluded. The eligible participants gave their written consent. The present study was approved by the Institutional Review Board of the Faculty of Medicine, Vajira Hospital (091/64 E).

Data collection

The pregnant women filled out the Thai Berlin Questionnaire at the time after the recruitment about the presence of habitual snoring. This identified the high risk for OSA in the previous month. They were also asked whether their bedpartner had some complaints. Demographic data were recorded, including age, height, pre-pregnancy weight and body mass index (BMI), gravidity, parity, gestational age, neck circumference, history of smoking, and pregestational medical condition. Neck circumference was measured at the middle of the neck between the mid-cervical spine and upper of the cricothyroid membrane by a research assistant trainee. Habitual snoring was defined as snoring a minimum of three or four times a week. Pregnancy-onset snoring was defined as habitual snoring that began after pregnancy. Chronic snoring has been defined as habitual snoring both prior to and during pregnancy. High risk for OSA, defined as two or more categories where the score is positive from the Thai Berlin Questionnaire. Results would be communicated to participants upon completion. Those identified as high-risk will be advised to consult with the otolaryngologist.

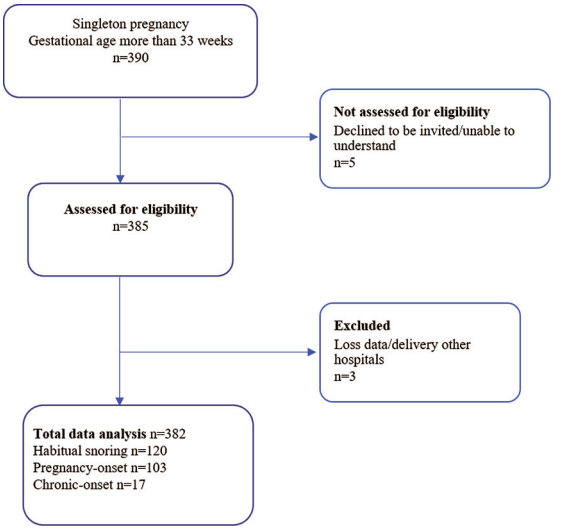

Figure 1. Recruitment flow chart.

After delivery, birth records were accessed to ascertain key variables, including weight gain during pregnancy, BMI at delivery, and mode of delivery.

Pregnancy outcomes comprised of maternal and fetal outcomes. Maternal outcomes consisted of hypertensive disorder in pregnancy, preterm birth, gestational diabetes mellitus (GDM), and emergency cesarean section. Neonatal outcomes consisted of birth weight, APGAR score, requirement of positive-pressure ventilation (PPV), and transfer to neonatal intensive care unit (NICU). These diagnoses were obtained from the medical coding using the International Classification of Diseases, Tenth Revision (ICD-10) and were cross-checked with all medical records.

Statistical analysis

Sample size was calculated based on available literature at the time of study design. The authors predicted that the frequency of snoring would be up to 35%[8] and an α error of 5%. The sample was required as at least 350 measured for the primary outcome. Ten percent of the sample size was calculated for missing data.

All data obtained were double-entered into a database and analyzed with IBM SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics included means and standard deviations as appropriate. Between-group comparisons of continuous were determined by chi-square test, Fisher's exact, and independent t-test. Logistic regression was used to determine the association between snoring pregnant and maternal-fetal outcomes after adjusting for potential covariate such as BMI at delivery. Odds ratio (OR) and 95% confidence interval (CI) were calculated. A p-value of less than 0.05 was considered statistically significant.

Results

Three hundred eighty-five pregnant women were invited to participate from a quota sampling method. Three pregnant women were later excluded due to childbirth in another hospital, resulting in no birth records available. The overall sample size was 382 participants.

Table 1 shows the demographics of the participants. The mean age was 28.38±6.32 years. The mean gestational age was 35.87±1.97 weeks. The mean height was 157.44±5.84 centimeters. The mean weight gain during pregnancy was 12.34±4.85 kilograms. There was no significant difference between the two groups regarding parity, smoking history, medical condition, and mode of delivery. Habitual snoring had significantly higher pre-pregnancy obesity compared to non-snorers at 20% versus 5.3% ($p<0.001$). In addition, BMI at delivery was 31.23±6.70 versus 27.49±4.62 kg/m² ($p<0.001$) and neck circumference was 34.45±3.29 versus 32.34±2.50 centimeters ($p<0.001$) in habitual snoring, which were significantly higher than non-snoring.

Table 2 shows that the prevalence of habitual snoring was 31.4% in the third trimester of pregnancy (95% CI 27 to 36), of which 27% being pregnancy-onset snoring and 4.4% being chronic-onset snoring. Of the 120 habitual snorers, 53 (44.2% of snorers), were identified as high risk by the Thai Berlin Questionnaire. The prevalence of pregnant women at high risk for OSA was 13.9% (95% CI 10 to 17).

Table 3 compared between habitual snoring and non-snoring groups. There were a significantly greater proportion in the habitual snoring than in the non-snoring that needed positive pressure ventilation of newborn (aOR 6.67, 95% CI 1.2 to 35.54). Other maternal and fetal outcomes were non-statistically significant different.

Table 4 shows the comparisons between high and low risk for OSA, according to the Thai Berlin Questionnaire. There were a significantly greater proportion of women in the high risk for OSA that had pregnancy induced hypertension (aOR 5.96, 95% CI 2.15 to 16.5), gestational hypertension (aOR 13.6, 95% CI 2.1 to 86.8), preeclampsia (aOR 4.07, 95% CI 1.09 to 15.2), severe preeclampsia (aOR 4.9, 95% CI 1.15 to 20.93), preterm birth (aOR 6.21, 95% CI 1.58 to 24.42), and low birth weight of newborn (aOR 6.09, 95% CI 2.5 to 14.87).

Discussion

The present was a prospective study aimed to study the prevalence of snoring in the third trimester of pregnancy, which was reported as 31.4%. This prevalence was comparable to previous studies in Thailand, which was 35.29%, however, the majority of the participants were in the second trimester[9]. In Chinese population, the prevalence of habitual snoring in the first trimester was 16.6%[3]. The prevalence of snoring increases across trimesters[10]. According to western studies, the third trimester prevalence of snoring ranges from 33% to 35%[4,11,12]. As a result, the prevalence of snoring in Thai pregnant women was comparable to western studies.

Among onset of snoring, 85.8% began snoring during pregnancy, while 14.2% reported chronic snoring. The results were similar to the previous studies[3,11]. The outcome demonstrated that pregnancy causes physiological changes that may enhance a woman's susceptibility to SDB[13,14].

Habitual snorers were significantly older and had significantly greater neck circumference, body weight, pre-pregnancy BMI than pregnant women who did not snore[15]. A cohort study survey also revealed a relationship between pre-pregnancy overweight and obesity status as the main contributor to the risk of habitual snoring. Consequently, losing weight prior to conception may lower the prevalence of snoring, better sleeping hygiene, and pregnancy outcomes. Moreover, obesity increases adverse pregnancy outcomes.

According to the outcomes calculated by adjusted odds ratio (aOR) by BMI at delivery,

Table 1. Demographic data of the participants

Variables	Total (n=382)	Habitual snoring (n=120)	Non-snoring (n=262)	p-value
Age (year); mean±SD	28.38±6.32	29.33±6.12	27.94±6.38	0.046*,T
Gravida; n (%)				0.106
1	154 (40.3)	48 (40.0)	106 (40.5)	
2	138 (36.1)	46 (38.3)	92 (35.1)	
3	59 (15.4)	22 (18.3)	37 (14.1)	
4+	31 (8.1)	4 (3.3)	27 (10.3)	
Para; n (%)				0.410
0	175 (45.8)	56 (46.7)	119 (45.4)	
1	142 (37.2)	47 (39.2)	95 (36.3)	
2	49 (12.8)	15 (12.5)	34 (13.0)	
3+	16 (4.2)	2 (1.7)	14 (5.3)	
Parity; n (%)				0.820
Nulliparity	175 (45.8)	56 (46.7)	119 (45.4)	
Multiparity	207 (54.2)	64 (53.3)	143 (54.6)	
Gestational age; mean±SD	35.87±1.97	36.05±1.95	35.79±1.98	0.240T
Height; mean±SD	157.44±5.84	158.09±6.02	157.14±5.74	0.140T
Pre-pregnancy BW; mean±SD	58.84±14.99	65.44±19.29	55.81±11.37	<0.001*,T
Pre-pregnancy BMI (kg/m^2); n (%)				<0.001*
Below 18.5	60 (15.7)	12 (10)	48 (18.3)	
18.5 to 24.9	193 (50.5)	50 (41.7)	143 (54.6)	
25 to 29.9	91 (23.8)	34 (28.3)	57 (21.8)	
30 or above	38 (9.9)	24 (20)	14 (5.3)	
BMI at delivery (kg/m^2); mean±SD	28.66±5.63	31.23±6.70	27.49±4.62	<0.001*,T
Weight gain during pregnancy (kg); mean±SD	12.34±4.85	12.86±5.06	12.10±4.74	0.158T
Neck circumference (cm); mean±SD	33.00±2.93	34.45±3.29	32.34±2.50	<0.001*,T
Smoking; n (%)				0.530F
Yes	2 (0.5)	1 (0.8)	1 (0.4)	
No	380 (99.5)	119 (99.2)	261 (99.6)	
Medical condition; n (%)				
Chronic hypertension	3 (0.8)	1 (0.8)	2 (0.8)	>0.999F
Pre-gestational diabetes mellitus	6 (1.6)	3 (2.5)	3 (1.1)	0.383F
Asthma	6 (1.6)	2 (1.7)	4 (1.5)	>0.999F
Mode of delivery; n (%)				0.070
Vaginal delivery	272 (71.2)	78 (65.0)	194 (74.0)	
Cesarean section	110 (28.8)	42 (35.0)	68 (26.0)	

BW=body weight; BMI=body mass index; SD=standard deviation

* Statistically significant at p<0.05 determined by chi-square test, F Fisher's exact, and T independent t-test

Table 2. Prevalence of snoring in pregnancy (total n=382)

Snorer	n	Percentage (total n=382)	95% CI
Habitual snoring	120	31.4	27 to 36
Pregnancy onset snoring	103	27	22 to 31
Chronic onset snoring	17	4.4	2 to 7
High risk by Thai Berlin Questionnaire	53	13.9	10 to 17

CI=confidence interval

habitual snoring was related to significantly greater risks of need positive pressure ventilation of newborn (aOR 6.67, 95% CI 1.25 to 35.54). In addition, snorers tended to increase risk of maternal complications such as gestational hypertension (OR 3.7, 95% CI 0.64 to 22.0. p=0.14) or GDM (OR 1.84, 95% CI 0.89 to 3.78), although not statistically significant different. The previous cross-sectional study[12] reported the new-onset snoring during pregnancy was a strong risk factor for gestational hypertension (OR 2.36, 95% CI 1.48 to 3.77, p<0.001) and preeclampsia (OR 1.59, 95% CI 1.06 to 2.37, p=0.024) but not gestational diabetes. Following a cohort study, women who snore frequently had a 2.5-fold increased chance of developing GDM than non-snorer (OR 2.50,

Table 3. Comparisons of maternal and fetal outcomes between habitual snoring and non-snoring groups

Outcomes	Habitual snoring (n=120); n (%)	Non-snoring (n=262); n (%)	Adjusted odds ratio* (95% CI)	p-value
Pregnancy induced hypertension	10 (8.3)	12 (4.6)	1.5 (0.59 to 3.85)	0.34
Gestational hypertension	5 (4.2)	2 (0.8)	3.7 (0.64 to 22.0)	0.14
Preeclampsia	5 (4.2)	8 (3.1)	1.13 (0.33 to 3.85)	0.85
Severe preeclampsia	4 (3.3)	6 (2.3)	1.32 (0.34 to 5.19)	0.69
Preterm birth	5 (4.2)	6 (2.3)	1.64 (0.45 to 5.93)	0.45
Gestational diabetes mellitus	20 (16.7)	19 (7.3)	1.84 (0.89 to 3.78)	0.10
Gestational diabetes mellitus with insulin control	8 (6.7)	6 (2.3)	1.53 (0.45 to 5.19)	0.49
Emergency cesarean section	27 (22.5)	40 (15.3)	1.49 (0.84 to 2.65)	0.18
Low birth weight	12 (10.0)	21 (8.0)	1.5 (0.69 to 3.26)	0.31
Macrosomia	5 (4.2)	5 (1.9)	1.32 (0.32 to 5.41)	0.7
APGAR score 1 minute <7	5 (4.2)	6 (2.3)	1.6 (0.44 to 5.82)	0.47
Positive pressure ventilation	6 (5.0)	2 (0.8)	6.67 (1.25 to 35.54)	0.03
Transfer to neonatal intensive care unit	3 (2.5)	1 (0.4)	4.4 (0.39 to 49.3)	0.23

CI=confidence interval

* Adjusted odds ratio by BMI at delivery

Table 4. Comparisons of maternal and fetal outcomes between high and low risk groups for OSA, according to Thai Berlin Questionnaire (total n=382)

Outcomes	High risk (n=53); n (%)	Low risk (n=329); n (%)	Adjusted odds ratio* (95% CI)	p-value
Pregnancy induced hypertension	10 (18.9)	12 (3.6)	5.96 (2.15 to 16.5)	<0.01
Gestational hypertension	5 (9.4)	2 (0.6)	13.6 (2.1 to 86.8)	0.01
Preeclampsia	5 (9.4)	8 (2.4)	4.07 (1.09 to 15.2)	0.04
Severe preeclampsia	4 (7.5)	6 (1.8)	4.9 (1.15 to 20.93)	0.03
Preterm birth	5 (9.4)	6 (1.8)	6.21 (1.58 to 24.42)	0.01
Gestational diabetes mellitus	12 (22.6)	27 (8.2)	1.9 (0.77 to 4.69)	0.16
Gestational diabetes mellitus with insulin control	7 (13.2)	7 (2.1)	3.02 (0.76 to 11.88)	0.11
Emergency cesarean section	14 (26.4)	53 (16.1)	1.68 (0.78 to 3.58)	0.18
Low birth weight	11 (20.8)	22 (6.7)	6.09 (2.5 to 14.87)	<0.01
Macrosomia	3 (5.7)	7 (2.1)	1.05 (0.17 to 6.5)	0.95
APGAR score 1 minute <7	2 (3.8)	9 (2.7)	0.95 (0.15 to 5.96)	0.95
Positive pressure ventilation	3 (5.7)	5 (1.5)	3.67 (0.69 to 19.54)	0.13
Transfer to neonatal intensive care unit	2 (3.8)	2 (0.6)	3.4 (0.29 to 39.53)	0.33

CI=confidence interval

* Adjusted odds ratio by BMI at delivery

95% CI 1.34 to 4.67)[16]. There was a correlation between SDB and glucose dysregulation, which led to the development of insulin resistance and glucose impairment during pregnancy[16].

The present study results revealed that newborns requiring positive pressure ventilation were significantly higher in infants born to habitual snorers than non-snorers (aOR 6.67, 95% CI 1.25 to 35.54). Eight newborns were evaluated, and four of them had prolapsed umbilical cords, fetal non-reassuring, shoulder dystocia, or vacuum extraction. Therefore, the authors do not consider that this data has clinical significance. Additionally, there was no significant difference in the 5-minute APGAR score between groups.

According to the Thai Berlin Questionnaire, 13.9% of pregnant women are at high risk for OSA. The result is similar to the 15% of pregnant women who had OSA, as identified and described by the American Academy of Sleep Medicine (AASM)[17]. A comparison between high-risk groups revealed greater significant differences with low-risk groups regarding pregnancy induced hypertension (aOR 5.96, 95% CI 2.15 to 16.5), gestational hypertension (aOR 13.6, 95% CI 2.1 to 86.8), preeclampsia (aOR 4.07, 95% CI 1.09 to 15.2), severe preeclampsia (aOR 4.9, 95% CI 1.15 to 20.93), preterm birth (aOR 6.21, 95% CI 1.58 to 24.42), and low birth weight

of newborn (aOR 6.09, 95% CI 2.5 to 14.87). The pregnancy outcomes may be comparable to previous studies. A systematic review and meta-analysis study[17] found that OSA was associated with an elevated risk of gestational hypertension, GDM, and preeclampsia ($p<0.001$). The pooled aOR were 1.97 (95% CI 1.51 to 2.56), 1.55 (95% CI 1.51 to 2.56), and 2.35 (95% CI 2.15 to 2.58). In addition to infant outcomes, OSA was related with an elevated risk of low birth weight (aOR 1.76, 95% CI 1.28 to 2.40)[18], and preterm birth (aOR 2.31, 95% CI 1.77 to 3.01), which is correlated with the present study.

The strength of the present study is the prospective design. Since there was a previous study of the prevalence of snoring in Thai pregnant women, the authors used the study as a reference and investigated more on pregnancy outcomes including pregnancy and fetal outcomes. The limitation of the present study is the recall bias caused by the participants being recruited in the third trimester of pregnancy. Nonetheless, having a bed partner was one of the inclusion criteria to get more information about presence, onset, and frequency of snoring, which minimizes recall bias.

The authors suggest that future studies should investigate early pregnancy and monitor every trimester until delivery. The large sample size and cohort study design may provide sufficient power to identify risk factors, the relationship between snoring and pregnancy outcomes, and minimize confounding factors.

Conclusion

The prevalence of snoring among Thai pregnant women is comparable to previous western studies, including onset during pregnancy and chronic snoring. Screening pregnant women at risk of the symptom may provide an early chance to lower the prevalence of snoring and adverse pregnancy outcomes.

What is already known on this topic?

Snoring is more frequent in pregnant women than in non-pregnant women. It also increases the risk of adverse pregnancy outcomes. The prevalence of snoring increases at each trimester.

What this study adds?

From the result of this study, the prevalence of snoring is 31.4% in the third trimester of pregnancy. Habitual snorers have more adverse pregnancy outcomes than non-snorers, particularly in persons diagnosed as high risk for OSA by the Thai Berlin Questionnaire.

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Conflicts of interest

The authors declare no conflict of interest.

References

1. Bourjeily G. Sleep disorders in pregnancy. Obstet Med 2009;2:100-6.
2. Izci Balserak B. Sleep disordered breathing in pregnancy. Breathe (Sheff) 2015;11:268-77.
3. Ge X, Tao F, Huang K, Mao L, Huang S, Niu Y, et al. Maternal snoring may predict adverse pregnancy outcomes: A cohort study in China. PLoS One 2016;11:e0148732.
4. Bourjeily G, Raker CA, Chalhoub M, Miller MA. Pregnancy and fetal outcomes of symptoms of sleep-disordered breathing. Eur Respir J 2010;36:849-55.
5. O'Brien LM, Bullough AS, Chames MC, Shelgikar AV, Armitage R, Guilleminault C, et al. Hypertension, snoring, and obstructive sleep apnoea during pregnancy: a cohort study. BJOG 2014;121:1685-93.
6. Laratta CR, Ayas NT, Povitz M, Pendharkar SR. Diagnosis and treatment of obstructive sleep apnea in adults. CMAJ 2017;189:E1481-8.
7. Suksakorn S, Rattanaumpawan P, Banhiran W, Cherakul N, Chotinaiwattarakul W. Reliability and validity of a Thai version of the Berlin questionnaire in patients with sleep disordered breathing. J Med Assoc Thai 2014;97 Suppl 3:S46-56.
8. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcántara C, et al. Racial/ethnic differences in sleep disturbances: The Multi-Ethnic Study of Atherosclerosis (MESA). Sleep 2015;38:877-88.
9. Puapornpong P, Neruntarat C, Manolerdthewan W. The prevalence of snoring in Thai pregnant women. J Med Assoc Thai 2010;93 Suppl 2:S102-5.
10. Cai XH, Xie YP, Li XC, Qu WL, Li T, Wang HX, et al. The prevalence and associated risk factors of sleep disorder-related symptoms in pregnant women in China. Sleep Breath 2013;17:951-6.
11. O'Brien LM, Bullough AS, Owusu JT, Tremblay KA, Brincat CA, Chames MC, et al. Snoring during

pregnancy and delivery outcomes: a cohort study. Sleep 2013;36:1625-32.
12. O'Brien LM, Bullough AS, Owusu JT, Tremblay KA, Brincat CA, Chames MC, et al. Pregnancy-onset habitual snoring, gestational hypertension, and preeclampsia: prospective cohort study. Am J Obstet Gynecol 2012;207:487.e1-9.
13. Laposky AD, Pemberton VL. Sleep-disordered breathing and pregnancy-related cardiovascular disease. J Womens Health (Larchmt) 2021;30:194-8.
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;16:574-82.
15. Frederick IO, Qiu C, Sorensen TK, Enquobahrie DA, Williams MA. The prevalence and correlates of habitual snoring during pregnancy. Sleep Breath 2013;17:541-7.
16. Qiu C, Lawrence W, Gelaye B, Stoner L, Frederick IO, Enquobahrie DA, et al. Risk of glucose intolerance and gestational diabetes mellitus in relation to maternal habitual snoring during early pregnancy. PLoS One 2017;12:e0184966.
17. Liu L, Su G, Wang S, Zhu B. The prevalence of obstructive sleep apnea and its association with pregnancy-related health outcomes: a systematic review and meta-analysis. Sleep Breath 2019;23:399-412.
18. Chen YH, Kang JH, Lin CC, Wang IT, Keller JJ, Lin HC. Obstructive sleep apnea and the risk of adverse pregnancy outcomes. Am J Obstet Gynecol 2012;206:136.e1-5.