



Exclusive

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Can pregnant women accurately report snoring? A pilot study



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Warland J,<sup>a</sup> Carpentieri J,<sup>b</sup> Dorrian J<sup>b</sup>.

*a* Mothers, Babies and Families: Health Research Group, School of Nursing and Midwifery, Level 4 Centenary Building, City East Campus, University of South Australia, SA 5000, Australia;

*b* Centre for Sleep Research, School of Psychology, Social Work and Social Policy, Level 7 Playford Building, City East Campus, University of South Australia, SA 5000, Australia.

## Students involved at the time of data collection:

Carpentieri J - Honours Student, University of South Australia

## Abstract

Sleep-Disordered Breathing (SDB) has been associated with possible negative outcomes, such as preeclampsia and foetal growth restriction. SDB screening tools have been developed for use within general populations. These included the use of self-reports and objective measurements. Seventeen pregnant women within their 34th to 37th week of pregnancy were recruited. Participants undertook an overnight study within their home and SDB symptoms were monitored using the Watch-PAT 200 and an infra-red video camera. The women were administered an online questionnaire comprised of the Multivariable Apnea Risk Index (MAP Index) and the Basic Nordic Sleep Questionnaire (BNSQ). More than half of our participants (n = 10) were identified as snorers while much fewer (n = 4) met the current cut off for diagnosis of mild SDB. Investigation of concordance and predictive value of self-report measures compared to standard video-scoring and Watch-PAT 200 determined SDB indicators suggests that self-reports may not provide an accurate assessment of SDB symptoms in late pregnancy. Self-report in this study, resulted in an underestimation of the number of participants who experienced SDB symptoms. This was a pilot study, with a small sample size. However, our study lends weight to others that found poor predictive value of common scales to detect SDB in pregnancy. Future study is therefore needed to validate screening tools, which may need to be a combination of measures.

## Keywords

Sleep disordered breathing; snoring; pregnancy; sleep quality.

## 1. Introduction

Sleep-disordered breathing (SDB) is a spectrum of breathing abnormalities that occur during sleep (1), ranging from primary snoring to obstructive sleep apnoea (OSA) (2). OSA is the most serious form of SDB, with repeated occurrences of partial (hypopnoeas) or complete (apnoeas) upper airway collapse (3). OSA also impacts on daytime performance including experiencing daytime sleepiness and fatigue (4). When snoring occurs, but is not associated with apnoeas and hypopnoeas during sleep and the individual has no daytime complaints, then this is known as 'simple snoring' (5). Snoring is quite common, it is estimated that approximately 40% of adult men and 20% of adult women are habitual snorers. Snoring is an audible indicator of increased upper airway resistance and as such is a sign of the presence of some degree of SDB (6).

Snoring in pregnant women can go unnoticed and this may also mean that SDB may go undiagnosed (7). This is problematic, because SDB is thought to be associated with poor pregnancy outcomes, such as foetal growth restriction, gestational diabetes and hypertension (8), especially if the SDB begins during pregnancy (7). SDB can also cause sleep disturbance, which may, in turn, increase negative outcomes such as preterm birth (9).

Accurate screening for SDB in pregnancy is important, because screening leading to treatment could assist in reduction of negative outcomes (10). That said, at present there is little evidence to support universal screening for SDB in pregnancy (11). This is because it has not yet been determined what degree of SDB may be clinically relevant. An Apnoea-Hypopnoea Index (AHI) of greater than 5 is used in many adult populations as the starting point for concern (12). However, it is not yet known if a pregnant woman should have a lower or higher alarm threshold (7, 11). Furthermore, screening indicators for SDB that are used in non-pregnant populations, such as body mass index and neck circumference (13) may not be appropriate in pregnancy due to normal physiological weight gain during this time.

Finally, several of the self-reported screening tools used in the general population, such as the Epworth Sleepiness Scale (ESS), ask about level of day time sleepiness which may be resulting from SDB (4). However, pregnant women are often sleepy during the day due to hormonal changes and the

physical demands of the pregnancy, meaning that this type of screening can also be unreliable in pregnancy especially if used in isolation.

Logic would suggest that a combination of screening tools for SDB may be useful in pregnancy. Work by Facco and others in 2012 (11) as well as Wilson and colleagues in 2013 (10) indicate that combining a range of objective (overnight sleep study, BMI) and self-reports of snoring may be the most useful way of screening for SDB in pregnancy, however, little is known regarding which combination of screening measures used in the general adult population may be the most useful in pregnancy, hence, further exploration and validation is necessary.

This pilot study aimed to investigate whether simply asking the woman if she snores as a basic screening tool for the presence of SDB is valid. Questions about snoring and other symptoms of SDB from the Basic Nordic Sleep Questionnaire (BNSQ) (14), and the Multivariable Apnea Risk Index (MAP Index) (15) were used. Additionally body mass index (BMI) and neck circumference were measured. Prospective studies show an association between increasing BMI and/or neck circumference and with an increased risk of SDB in both the general (13, 16) and pregnant populations (17, 18). We therefore included these measures in our analysis to provide further exploration of their value for identifying women at risk of SDB in pregnancy.

## 2. Materials and Methods

### 2.1. Participants

Participants ( $\geq 18$  y) in late pregnancy, (34 to 37 weeks), when SDB is likely to be at its peak prevalence (7), were recruited. Exclusion criteria included: pre-pregnancy BMI  $> 35\text{kg/m}^2$ , high blood pressure or existing diagnosis of SDB. Recruitment occurred from July to October 2014 through flyers displayed on social media forums, such as Facebook, and snowball sampling, i.e. participants inviting other pregnant family and friends to participate (19). Of the 19 women originally recruited, 17 participated. One participant gave birth before she was able to participate; the other cancelled due to illness. The modal age bracket was 31 - 35 years with an average gestational age of 36.4 weeks. The

average BMI of participants was 29.7kg/m<sup>2</sup>. The majority of the participants within this study were having their first baby (70.6%) (Table 1). Human research ethics committee approval from the participating University was gained. Both the woman and her bed partner were given an information sheet about the study and gave their written consent.

**Table 1. Descriptive information for the 17 study participants.**

Variable	Level	n/ Mean ±SD
<b>Maternal Age</b>	18 - 25y	5
	26 - 30y	4
	31 - 35y	6
	36 - 40y	2
<b>Smoked in last 4y</b>	yes	1
	no	16
<b>Family History of SDB</b>	yes	3
	no	14
<b>Frequent Nasal Stuffiness</b>	yes	2
	no	15
<b>Parity</b>	First baby	12
	have 1 - 2 children	4
	have 3+ children	1
<b>Gestational Age (weeks)</b>		36.4 ± 1.2
<b>Neck Circumference (cm)</b>		34.1 ± 1.9

## 2.2. Procedure

Each participant completed a single-night sleep study in their own home where they wore the Watch-PAT 200 and were filmed as they slept. Weight, height and neck circumference were measured at the beginning of the study. Within 24 hours of study completion, participants completed an online survey, which included self-report measures of SDB symptoms.

## 2.3. Measures

The BNSQ (14) is a 21 question survey assessing a variety of sleep complaints such as snoring, napping and daytime sleepiness. The questions used in this study were: "Do you snore while sleeping? (1 = never or < once/month; 2 = < once/week; 3 = 1 - 2 days/week; 4 = 3 - 5 days/week; 5 = daily/almost daily). The question about symptoms of SDB used was: "Have you had breathing pauses (sleep apnoea) at sleep (have other people noticed that you gave pauses in respiration when you sleep)?" (1 = never or < once/month; 2 = < once/week; 3 = 1 - 2 days/week; 4 = 3 - 5 days/week; 5 = daily/almost daily). For the purposes of analysis, two cut-offs were used to investigate the sensitivity of these questions for identifying snoring and other SDB symptoms: responses > 1 (i.e. those who reported symptoms at least once per month); and responses > 2 (i.e. those who reported symptoms at least once per week).

The MAP Index (15) contains 13 self-report questions that are commonly associated with sleep disorders. Participants respond to the question: "During the last month, on how many nights or days have you been told the following?" after a series of prompts (1 = never; 2 = rarely, < once/week; 3 = sometimes, 1 - 2 times/week; 4 = frequently, 3 - 5 days/week; 5 = always, 5 - 7 times/week). The questions used for this study asked about "loud snoring," "snorting or gasping," and "breathing stops or you choke or struggle for breath." For the purposes of analysis, two cut-offs were used to investigate the sensitivity of these questions for identifying snoring and other SDB symptoms: responses > 1 (i.e. those who reported symptoms at least rarely); and responses > 2 (i.e. those who reported symptoms at least once per week).

Currently there are no guidelines or norms for recording and quantifying snoring noise (20). In order to address this we used an approach that is consistent with common practice in clinical sleep laboratories, where snoring is rated by the

sleep technician (21, 22). Using the video data, whether or not the participant was snoring over 5-minute periods was rated by the second author every 30-minutes throughout the night, and participants were classified as; non-snorer, mild snorer, moderate snorer and severe snorer. Mild snorers had a steady, low snore, and severe snorers had a frequent, loud snore during the majority of viewing intervals.

The Watch-PAT 200 is an ambulatory device which can be used to identify and diagnose SDB in a home environment. It is worn on the hand and wrist and measures changes in blood oxygen saturation, peripheral arterial tone, snoring and respiratory events that indicate SDB. Respiratory Disturbance Index (RDI) and AHI are calculated by the zzzPAT software (23), which uses information from the peripheral arterial tonometry (PAT) probe and the pulse oximetry probe. The Watch-PAT 200 has been validated against portable polysomnography in pregnancy for identification of SDB in the third trimester (24).

The Watch-PAT 200 also has a snore sensor containing a microphone which was placed on the sternum. The zzzPAT software uses a snoring threshold determined by the manufacturer of > 45dB (23) and calculates the total number of minutes over the night spent snoring.

An infrared-capable video camera was focused on the participants' side of the bed.

## 2.4. Analysis

Of the 17 participants, 15 had viable Watch-PAT 200 data (failed to initialize  $n = 2$ ) and 14 had video camera data (women opted to not turn on the camera  $n = 2$ , the audio on the video file was corrupt  $n = 1$ ). One participant did not complete the snoring question in the MAP Index.

The number of participants identified as snorers by video (standard measure) was compared with self-report questions from the BNSQ and the MAP, using the two cut-offs (> 1 or > 2) as described above (comparison measures), and snoring as scored by the Watch-PAT 200 dB meter (comparison measure). The number of participants identified as potentially having SDB from the Watch-PAT (on the basis of an RDI > 10 or an AHI > 5, standard measures) was compared to self-report from the BNSQ and MAP using the two cut-offs (> 1 or > 2) as described above (comparison measures). The total

number of participants classified in the same way by both standard and comparison measures (concordance), true positives (TP: those identified as having SDB symptoms by both measures), true negatives (TN: those identified as not having SDB symptoms by both measures), false positives (FP: those identified as having SDB symptoms by comparison measures, but not by standard measures), and false negatives (FN: those identified as not having SDB symptoms by comparison measures but not by standard measures) were calculated. This allowed calculation of sensitivity ( $TP/(TP+FN)*100$ ), specificity ( $TN/(TN+FP)*100$ ), positive predictive value ( $PPV = TP/(TP+FP)*100$ ), negative predictive value ( $NPV = TN/(TN+FN)*100$ ).

Independent samples t-tests were used to examine differences in BMI and neck-circumference in video-rated snorers versus non-snorers and RDI/AHI-indicated SDB v non-SDB.

## 3. Results

Ten participants (71%) were identified as snorers by video-scoring. BNSQ and MAP reports of snoring were concordant with video-determined snoring in  $\leq 50\%$  of participants ( $n = 7$ ). The Watch-PAT 200 dB measure of snoring was concordant with video-determined snoring in 35% ( $n = 5$ ) participants (Figure 1, left). Specificity was 86% for MAP > 2 and 76% for BNSQ > 2 compared to video-determined snoring. Sensitivity, specificity, PPV and NPV were  $\leq 55\%$  for all other comparisons to video-determined snoring (Figure 1, right).

Four participants (27%) had an RDI greater than 10 and/or AHI greater than 5. While the correlation between RDI and AHI was  $r = 0.83$ , one person had an RDI of 12.8 and an AHI of 4.8, and another had an RDI of 9.6 and an AHI of 7.0. Highest concordance between self-reports and RDI/AHI measures was for BNSQ > 2 ( $n = 8$ , 53%) (Figure 1, left). While sensitivity and NPV were  $\geq 67\%$  for self-reports compared to RDI > 10 and AHI > 5, specificity and PPV were  $\leq 45\%$  (Figure 1, right).

There were no significant differences in BMI or neck circumference in snorers compared to non-snorers, or those with indicators for SDB compared to those without (Table 2).

Table 2. Independent Samples t-test (equal variances not assumed) comparing BMI and neck-circumference in video-rated snorers v non-snorers and RDI/AHI-indicated SDB v non-SDB.

Objective measure	Classification Category		tdf	
	Video-rated snorers (n = 10)	Video-rated non-snorers (n = 4)	t12	p
BMI (kg/m <sup>2</sup> )	29.5 (4.3)	30.6 (6.5)	0.303	0.777
neck circ. (cm)	33.7 (2.1)	34.0 (1.2)	0.384	0.709
	RDI > 10 (n = 4)	RDI ≤ 10 (n = 10)	t13	p
BMI (kg/m <sup>2</sup> )	32.0 (6.0)	28.24 (4.6)	1.129	0.318
neck circ. (cm)	34.2 (1.6)	34.0 (2.3)	0.198	0.848
	AHI > 5 (n = 4)	AHI ≤ 5 (n = 10)	t13	p
BMI (kg/m <sup>2</sup> )	31.8 (6.0)	28.3 (4.6)	1.040	0.352
neck circ. (cm)	34.0 (1.2)	34.1 (2.3)	0.147	0.886

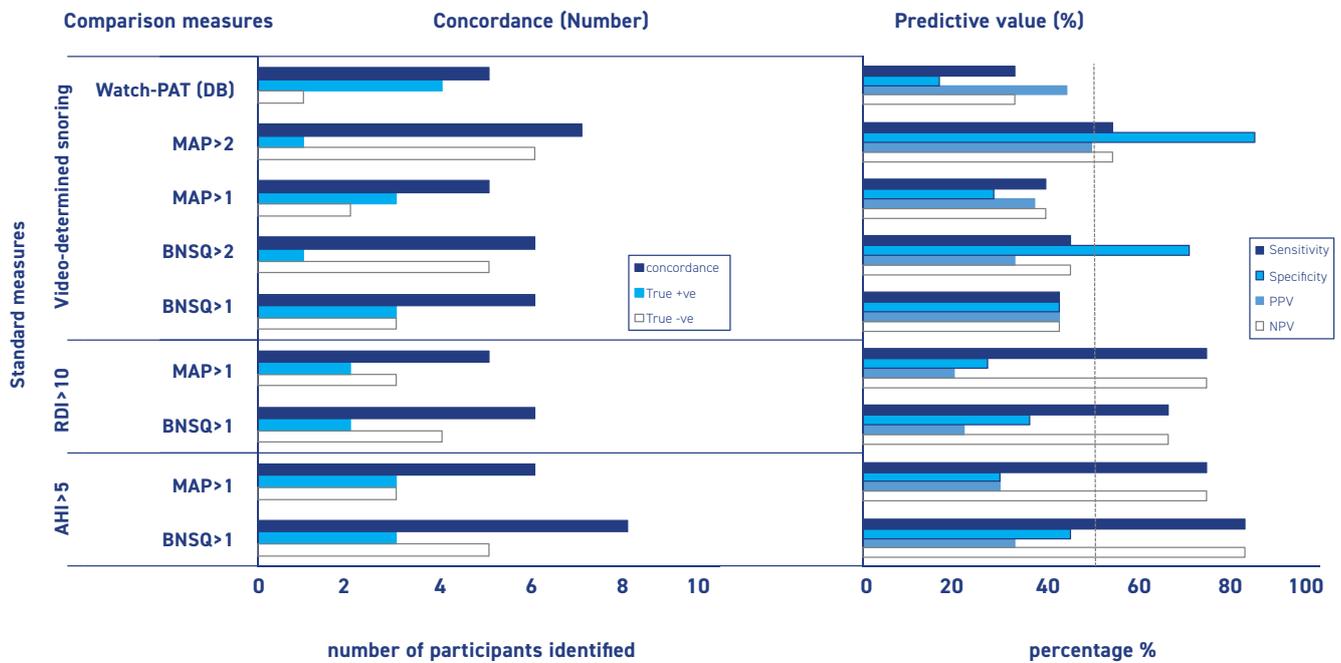


Figure 1. Concordance, true positives (+ve) and true negatives (-ve) in absolute participant numbers (left) and Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) (right). Upper Panel: Comparison between the video-scored measure of snoring (standard measure) and the Watch-PAT 200 DB meter and self-report measures (MAP and BNSQ) (comparison measures). Middle and Lower Panels: Comparison between Watch-PAT 200 indicators of SDB (RDI > 10, AHI > 5) (standard measures) and self-report measures (MAP and BNSQ) (comparison measures).

## 4. Discussion

This study aimed to determine if self-report tools in late pregnancy may be used as a screen for the presence of SDB. More than half of our participants ( $n = 10$ ) were identified as snorers while much fewer ( $n = 4$ ) met the current cut off for diagnosis of mild SDB ( $AHI \geq 5$ ). Investigation of concordance and predictive value of self-report measures compared to standard video-scoring and Watch-PAT 200 determined SDB indicators suggests that self-reports may not provide an accurate assessment of SDB symptoms in late pregnancy. This is consistent with previous work finding low-moderate predictive capacity of MAP index measures compared to PSG for predicting SDB in pregnancy (10). Self-report in this study, resulted in an underestimation of the number of participants who experienced SDB symptoms.

Combining self-report with objective measures such as BMI and neck circumference when screening for SDB has been validated within general adult populations (25, 26). However, there were no differences in BMI or neck circumference in snoring or potential SDB groups in our study. It may be that these measures are not as reflective of SDB risk during pregnancy as it is normal for pregnant women to gain weight, which may also result in increase in neck circumference (27, 28). Interestingly, there has been recent work towards development of a model using three factors, obesity ( $BMI \geq 32$ ), snoring volume and tiredness upon waking, to accurately predict the presence of SDB in pregnancy (10). While our study suggests that self-reports of snoring and SDB symptoms may not be accurate in this population, perhaps combining them with other measures such as tiredness upon waking, may be more effective.

The snore sensor of the Watch-PAT 200 was sensitive to ambient noise other than snoring (for example: television, fans in the room and outside traffic) and this issue may have meant all 'snore' data recorded by the Watch-PAT 200 was unreliable. Indeed, there was a relatively poor concordance between the Watch-PAT 200 measure of snoring and video-determined snoring.

This was a pilot study, with a small sample size. However, our study lends weight to other studies which found poor predictive value of the scales used in the general population to detect SDB in pregnancy. Future study is therefore needed to validate screening tools, which may

need to be a combination of measures. Such a tool would need to take account of the normal physiological changes of pregnancy but also should be administered in pregnancy early enough to allow diagnosis of SDB with enough time for any intervention (such as CPAP) to be effective in improving maternal and foetal outcome.

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