Sleep Medicine 125 (2025) 168–176

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

General Practice Sleep Scale – The "GPSS" – A proposed new tool for use in General Practice for risk assessment of Obstructive Sleep Apnoea

Timothy Howarth [a,b], Joe Hedger [c], Winnie Chen [c,d,e], Himanshu Garg [f], Subash S. Heraganahally [a,f,g,*]

[a] Darwin Respiratory and Sleep Health, Darwin Private Hospital, Darwin, Northern Territory, Australia
[b] Department of Technical Physics, University of Eastern Finland, Kuopio, Finland
[c] Flinders University, College of Medicine and Public Health, Darwin, Northern Territory, Australia
[d] General Practice, Danila Dilba, Aboriginal Health Service, Darwin, Northern Territory, Australia
[e] Menzies School of Health Research, Darwin, Northern Territory, Australia
[f] Department of Respiratory and Sleep Medicine, Royal Darwin Hospital, Darwin, Northern Territory, Australia
[g] School of Medicine, Charles Darwin University, Darwin, Northern Territory, Australia

ARTICLE INFO

Keywords:
Clinical tools
Diagnosis
Differential
Outcome assessment
Practice management
Risk assessment
Sleep disorders

ABSTRACT

Background: This pilot study investigated a new simplified OSA screening tool that could be used in primary care/GP settings – the "GPSS" tool – "General Practice Sleep Scale" and compared against common existing OSA screening tools.

Methods: A convenience sample of patients attending the respiratory and sleep clinic in the Northern Territory of Australia were included if they completed the GPSS prior to undergoing a diagnostic polysomnography. The GPSS contained 9 questions to provide information on: sex, age, body mass index, neck circumference, snoring, witnessed apnoeas, morning tiredness, daytime sleepiness and presence of hypertension/diabetes/heart disease/depression. Presence of OSA was defined as an apnoea-hypopnoea index of ≥15/hour. The GPSS scoring was developed via log odds of regression predictions for each GPSS question upon OSA.

Results: 159 patients (65 % male, median age 45 years) were enrolled. A minimum score of 1 was assigned to GPSS questions, up to 5 for the strongest predictor (neck circumference). The median total GPSS score was 13 (IQR 9, 16) (maximum 22) and correlated strongly with OSA (AUC 0.812 (95 % CI 0.744, 0.881)). Categorised into low (0–7), moderate (8–13) or high risk (>13), a moderate or severe score had sensitivity 100, specificity 34.9 %. The GPSS significantly outperformed the Epworth Sleepiness Scale, Berlin questionnaire and OSA-50, and was comparable but slightly improved against the STOP-Bang.

Conclusions: The proposed GPSS tool could be of use in general practice settings. Further prospective research is warranted to test the applicability and adaptability of the GPSS tool in wider population settings.

1. Introduction

Obstructive sleep apnoea (OSA) is one of the most common forms of sleep disorder encountered in day-to-day clinical practice, with prevalence as high as 38 % in the general adult population, with moderate to severe cases present in 6–17 % [1–4]. An integral component in clinical decision making at the primary health care/General Practice (GP) level is the assessment of individuals risk factors for the presence of OSA. Examples of such risk factors include male sex, obesity (body mass index (BMI)), neck circumference, presence of medical co-morbid conditions such as, but not limited to cardiovascular disease, stroke and hypertension [5]. The risk assessment is crucial in clinical decision making to refer at risk patients for further testing to confirm the presence of OSA by undergoing an overnight sleep study (Polysomnography (PSG)) [6,7].

There are several well-established screening tools that are widely utilised for this purpose of which the most common are: (i) The Epworth Sleepiness Scale (ESS); (ii) STOP-Bang screening tool; (iii) Berlin Questionnaire; (iv) OSA-50; (v) Top End Sleepiness scale (TESS) (for Australian Indigenous people) [8–12]. However, the aforementioned screening tools test for differing risk factors, and may have inherent deficiencies in addressing all of the risk factors for OSA. The ESS tool

* Corresponding author. Department of Respiratory and Sleep Medicine, Royal Darwin Hospital, Darwin Respiratory and Sleep Health, Darwin private Hospital, Tiwi, Darwin, NT, Australia.
E-mail addresses: Subash.heraganahally@nt.gov.au, subash.heraganahally@flinders.edu.au, subash.heraganahally@cdu.edu.au (S.S. Heraganahally).

https://doi.org/10.1016/j.sleep.2024.11.022
Received 15 September 2024; Received in revised form 12 November 2024; Accepted 12 November 2024
Available online 21 November 2024
1389-9457/© 2024 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Abbreviation list

AHI	Apnoea hypopnea index
AUC	Area under the curve
BMI	Body Mass Index
CI	Confidence interval
DPH	Darwin Private Hospital
DRSH	Darwin Respiratory and Sleep Health
ESS	Epworth Sleepiness Scale
GP	General Practice
GPSS	General Practice Sleep Scale
IQR	Interquartile range
NT	Northern Territory
OSA	Obstructive sleep apnoea
OR	Odds ratio
PSG	Polysomnography
RDH	Royal Darwin Hospital
ROC:	Receiver operator characteristics
TEHS	Top End Health Service
TESS	Top End Sleepiness scale

only assesses daytime sleepiness and none of the other risk factors for OSA. The Berlin questionnaire and OSA-50 do not include neck circumference measures which are clinically significant for OSA risk assessment [13]. Moreover, some of the screening tools, such as the STOP-Bang and OSA-50 have a significant age and gender bias as they were developed and validated predominantly to include patients over 50 years and males [14]. Indeed, OSA is prevalent in at risk younger individuals and adult women of all ages [15,16]. Additionally, the STOP-Bang only utilises a binary risk classification for its' components (i.e. BMI $\geq$35 kg/m^2), when risk increases are not always a binary or linear process. As a result, overall, the existing OSA screening tools have varying sensitivity and specificity across populations and settings [6, 17–22].

Nevertheless, despite the availability of various screening tools in place, underdiagnosis of OSA continues [6,23], including in GP settings [24]. Untreated sleep apnoea has been shown to lead to adverse metabolic health consequences and to overall mortality [25]. In Australia, the overall health care expenditure related to sleep disorders was estimated to be around $7494 million USD [26]. This was in 2004, and the prevalence of sleep disorders has likely been increasing in line with an increase in obesity and an ageing population. However, effective early diagnosis and treatment can significantly reduce the harms associated with sleep disorders, including OSA [27]. Hence, it is critical to develop a comprehensive OSA screening tool for use at the primary care level and in GP settings to adequately identify at risk OSA patients.

In line with what is observed in other Australian jurisdictions [28], OSA is also reported to be highly prevalent in the Northern Territory (NT) Australian population [16,29]. Several studies from our centre have reported on various aspects of OSA from the Top End Health Service (TEHS) region of the NT of Australia [16,29–41], including the TESS screening tool that was developed specifically for the remote Indigenous population [12,42]. This places us in an ideal clinical situation to develop and test an OSA screening tool in a population with a high prevalence of OSA. Therefore, we developed a simple nine question OSA risk assessment tool that may be adopted and used in the GP setting - the "General Practice Sleep Scale" (GPSS) - and piloted it in a convenient random sample to test the accuracy of the GPSS tool to identify at risk patients with OSA. The aim of this study was primarily to develop the scoring of the GPSS and test its accuracy in the prediction of OSA against the gold standard of PSG, and secondarily to compare its efficacy against commonly utilised existing OSA screening tools (ESS; STOP-Bang; OSA-50; Berlin questionnaires) amongst patients presenting to the respiratory and sleep clinic in the TEHS region in the NT of Australia.

2. Methods

2.1. Study setting

The NT is an Australian federal territory occupying the central-northern region of Australia. The TEHS region within the NT covers approximately 35 % or 475,338 km^2 of the total area of the NT and consists of an estimated population of 195,000 people, representing 79 % of the total NT population [43,44]. This study was conducted at the respiratory and sleep division based at the Royal Darwin Hospital (RDH), a university affiliated tertiary care teaching hospital and Darwin Respiratory and Sleep Health (DRSH), Darwin Private Hospital (DPH). In the Australian context, for GPs to directly request a PSG, the patient needs to demonstrate moderate–severe OSA as assessed on screening questionnaire by fulfilling the following criteria: ESS $\geq$8 and one of either STOP-Bang $\geq$3, OSA-50 $\geq$ 5, or 'high risk' on the Berlin questionnaire [45]. However, patients can be referred for assessment for the presence of OSA through other specialist pathways on clinical grounds.

2.2. Ethics

This study was approved by the Human Research Ethics Committee of the NT Department of Health/TEHS and Menzies School of Health Research. (Reference No: HREC 2021–4218). Informed consent by the study participants was not obtained for the included study participants, as the study was retrospective in nature and moreover, the ethics committee approved waiver for consent. Moreover, all included study participants voluntarily answered the GPSS questionnaire that was developed for routine screening assessment for at risk OSA patients in the TEHS, NT region. Patients underwent a diagnostic sleep study only as per the discretion of the treating respiratory/sleep physician irrespective of prior GPSS assessment tool completion or score.

2.3. The GPSS-OSA screening questionnaire

The GPSS questionnaire was designed in such a way that it could be mostly answered by the patients, by themselves while attending a clinic appointment prior to seeing a medical practitioner or during clinic consultation with the medical practitioner. The questionnaire consisted of items broadly representing two main clinical components (Box 1). These are the patients' base line clinical/demographic information (part A) and symptoms or signs related to OSA (part B). The first two questions in part B assess presence of nighttime OSA symptoms; the second two questions assess the presence of daytime OSA symptoms; the last question assesses the presence of medical co-morbidities that are known to be associated with OSA. All part B questions are answered by a simple "Yes" or "No" by the patient. Development of the scoring for the GPSS is described below under the sub-heading – "GPSS score development and statistical analysis".

2.4. Study participants and questionnaire administration

This was a retrospective study involving a convenient and random sample of patients who were willing to complete the questionnaire voluntarily while attending the respiratory and sleep clinic appointments at the RDH and DPH. The GPSS questionnaire was also distributed to local General practice (GP) clinics in the Darwin urban area and remote health clinics visited by the respiratory sleep outreach team in the TEHS region [40]. Patients were included if identified to have completed the GPSS questionnaire prior to undergoing a diagnostic PSG at DRSH. The questionnaires were given to individual patients by the medical clinic administrative personnel or by a clinic nurse, and patients were requested to fill out the details while waiting to be seen by the

Box 1
Showing the two components used in the GPSS - OSA assessment tool

(A) base line demographic and clinical information;
  a. age
  b. sex/gender
  c. height/weight and BMI
  d. neck circumference or collar size
(B) The second component specifically represents sleep related domains;
  a. Do you snore loudly? Does your partner complain of you snoring – does it disturbs others?
  b. Has anyone ever seen you stop breathing, choking or gasping for air in your sleep?
  c. Do you wake tired or unrefreshed in the morning?
  d. Do you fall asleep easily (e.g. during meetings, watching TV etc)?
  e. Do you suffer from high blood pressure, Diabetes, Heart disease or Depression?

medical practitioner. For those patients included while undergoing a diagnostic PSG, the questionnaire was given to the patients by the sleep technologists. No assistance was provided to answer the questionnaire until or unless requested by the patients, in order to assess the feasibility for patients themselves to complete the form independently. In addition to the GPSS questionnaire, other screening tools completed by the patients prior to undergoing an initial sleep study (PSG) were recorded when available (i.e. ESS; STOP-Bang; OSA-50; Berlin questionnaires).

2.5. Polysomnography (PSG) data

All PSGs were performed at the DRSH facility currently accredited by the National Association of Testing Authorities, Australia and the Australian Sleep Association. The diagnostic PSGs were performed as either Level 1 studies (in-Lab, with a sleep technologist in attendance) or as Level 2 sleep studies (un-attended). For the purposes of this study, the presence of OSA was defined by an Apnoea-Hypopnoea Index (AHI) of $\geq$15/hour (at least moderate severity). As per usual protocol at the DRSH centre, clinical and demographic characteristics including: age, sex, height, weight, BMI, smoking history and medical co-morbid conditions; such as the presence of diabetes, hypertension, heart disease, including presence of mental health disorders are routinely collected for patients undergoing a sleep study (PSG). Further details regarding PSG testing protocol as per recommended guidelines are available from a previous report from our centre [28]. Note that presence of comorbidities (diabetes, hypertension, heart disease and depression) are also asked in the GPSS, as well as collected prior to PSG testing. For the purposes of this study when testing the validity of the GPSS, we utilised only what the patient had self-reported in the GPSS. Participants were excluded from the analysis if the sleep study was considered failed (i.e. AHI was not available), or if the GPSS was not completed. In the case of participants who had more than one visit during the study period, only data from the first GPSS and first PSG was utilised.

2.6. GPSS score development and statistical analysis

In order to derive and validate the scoring associated with each question of the GPSS, the participant cohort was randomly split to either the development cohort (n = 79) (used to develop the scores associated with each question of the GPSS) or the validation cohort (n = 80) (used to validate the developed scores) via a random number generator within STATA IC 15 (College Station, Texas). Age was split into three age categories based on inspection of the area under the curve (AUC) receiver operator characteristics (ROC) graph to maximise the univariate AUC for OSA. Neck circumference was split into three categories in the same fashion, though assessed individually by male and female due to differences in neck size distribution. BMI was categorised as normal weight, overweight, obese and morbidly obese on the basis of previous research showing greater risk of OSA with increasing BMI. Univariate logistic regression, reporting log odds for association with OSA, were conducted for each of the nine questions within the GPSS, namely: sex, BMI category, age category, neck circumference category, self-reported snoring, witnessed apnoeas, morning tiredness, daytime sleepiness, and self-reported hypertension/diabetes/heart disease/depression. The score for each parameter was defined by the logistic regression beta coefficient rounded to the nearest 0.5, with a minimum score for each parameter set at 0.5. The total GPSS score was thus the sum of each parameter score within the GPSS. For ease of use of the GPSS by patients and practitioners however, the scoring was doubled, such that only whole number scores were assigned. The total score was then divided into three categories in a similar fashion as other existing questionnaires (low risk, moderate risk and high risk), based on inspection of points which maximised the AUC. The accuracy of the GPSS total score was tested in the validation cohort via AUC ROC analysis, and the accuracy of the three-group categorisation additionally shown through the sensitivity, specificity and correct classification of patients OSA status. The overlap between the GPSS and other screening tools was tested in the total cohort of patients (for whom data was available) via both Pearsons pairwise correlation reported as R^2, and via Cohens Kappa, reporting the Kappa and p-value. To showcase the efficacy of the GPSS against existing questionnaires, we additionally conducted AUC ROC analysis of the ESS (total score), the Berlin questionnaire (categorised as low risk or high risk), the OSA-50 (total score) and the STOP-Bang (total score and categorisation as low, moderate or high-risk) for participants who had these data available. To further assess the efficacy of the GPSS against existing screening tools we retrospectively categorised those who fit the current direct referral route (described above) through either the STOP-Bang, OSA-50, Berlin questionnaire or any combination of the three and compared the proportion of those with OSA against those who fit our GPSS risk criteria and had OSA via two-tailed proportions z-test.

3. Results

3.1. Clinical and demographic data

A total of 159 patients completed the GPSS and had an acceptable diagnostic PSG. The median age of the included patients was 45 years (IQR 34, 54), the majority were male (65 %) and the median BMI was 31 kg/m^2 (IQR 27.7, 37.7) (Supplementary Table 1).

3.2. GPSS and OSA assessment

Several aspects of the GPSS did not show a statistically significant association with OSA in this study (sex, witnessed apnoeas, morning tiredness, daytime sleepiness and presence of comorbidities) – however, they were included on the basis of previous research which has shown significant correlations between these parameters and OSA. In the development cohort, a normal range BMI predicted absence of OSA perfectly and was thus omitted from the model and overweight BMI parameter was used as the reference (Table 1). A baseline score of 0.5 was thus assigned to overweight and the scores for obese and morbidly obese were calculated as 0.5+Beta value, and then rounded to the nearest 0.5. A BMI ≥40 kg/m^2 and a neck circumference of >46 cm for males or >38 cm for females showed the strongest associations with OSA. Upon review, in order to make the scoring easier for patients and healthcare staff, we opted to double the score assigned for each parameter so only whole numbers were present.

3.3. Regression analysis

Following the logistic regressions, the total maximum score of the GPSS was 22 points. In the development cohort the median GPSS score was 13 (IQR 9, 16) and an increasing score showed a significant association with OSA (OR 1.46 (95 % CI 1.23, 1.72), Pseudo $R^2 = 0.300$, $p < 0.001$) and an AUC ROC of 0.839 (Fig. 1).

3.4. Risk assessment

From inspection of the AUC ROC (Fig. 1) two cutpoints were determined to define a moderate risk (GPSS >7) and a high risk (GPSS >13) for OSA. In the development cohort 11 patients ($n = 0$ (0 %) with OSA) were in the low risk category, 29 ($n = 11$ (37.9 %) with OSA) in the moderate risk and 39 ($n = 32$ (82.1 %) with OSA) in the high risk category. The AUC for the three category model was 0.814 (95 % CI 0.727, 0.901) with a moderate or severe score having sensitivity 100 %, specificity 30.6 % & correctly classified 68.4 %, while a severe score alone had sensitiviy 74.4 %, specificity 80.6 % & correctly classified 77.2 % of patients.

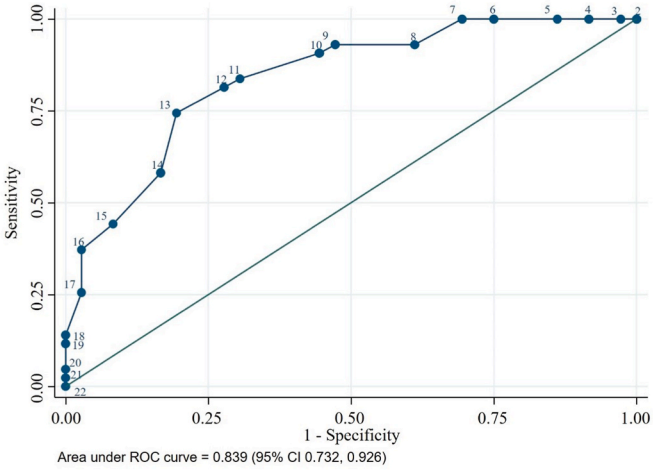


Fig. 1. AUC ROC for the GPSS in the development cohort
Abbreviations: AUC, Area under the curve; GPSS, General practice sleep scale; ROC, Receiver operator characteristic; CI, Confidence interval.

3.5. Validation cohort data

In the validation cohort the median GPSS score was 13.5 (IQR 9.5, 15.5). The GPSS overall retained a significant association with OSA (OR 1.37 (95 % CI 1.17, 1.59), Pseudo $R^2 = 0.219$, $p < 0.001$). Eleven patients were categorised as low risk ($n = 0$ (0 %) with OSA), 29 as moderate risk ($n = 19$ (65.5 %) with OSA) and 40 ($n = 34$ (85 %) with OSA) as high risk. The AUC for the three category model was 0.783 (95 % CI 0.676, 0.890) with a moderate or severe score having sensitivity 100 %, specificity 40.7 % & correctly classified 80 %, while a severe score alone had sensitiviy 64.2 %, specificity 77.8 % & correctly classified 68.8 % of patients. A breakdown of the univariate logistic regression results of the GPSS score within the validation cohort is available in Supplementary Table 2.

3.6. Comparison against other established sleep assessment tools

In our total cohort ($n = 159$) all participants had the ESS and the STOP-Bang available, 128 (80.5 %) had completed the OSA-50, and 127 (79.9 %) the Berlin questionnaire. The total GPSS score did not show any

Table 1
Results of univariate logistic regression for presence of OSA by each aspect of the GPSS in the development cohort.

Clinical parameters	Clinical variables	Number (%)	Beta (95 % CI)	Initial score	Doubled score
Sex	Female	29 (36.7 %)	Reference	–	–
	Male	50 (63.3 %)	0.84 (−0.1, 1.77)	1	2
BMI (kg/m^2)	Normal weight (BMI <25 kg/m^2)	6 (7.6 %)	Omitted	–	–
	Overweight (BMI 25 < 30 kg/m^2)	27 (34.2 %)	Reference	0.5	1
	Obese (BMI 30 < 40 kg/m^2)	33 (41.8 %)	0.65 (−0.38, 1.69)	1	2
	Morbidly obese (BMI ≥40 kg/m^2)	13 (16.5 %)	1.93 (0.24, 3.61)	2.5	5
Age (years)	≤34 years	24 (30.4 %)	Reference	–	–
	34 ≤ 45 years	13 (16.5 %)	0.54 (−0.84, 1.92)	0.5	1
	>45 years	42 (53.2 %)	1.5 (0.42, 2.57)	1.5	3
Neck circumference (cms)	M ≤ 39.5 cm, F ≤ 35.5 cm	22 (27.8 %)	Reference	–	–
	M 39.5 ≤ 46 cm, F 35.5 ≤ 38 cm	34 (43 %)	2.11 (0.82, 3.4)	2	4
	M > 46 cm, F > 38 cm	23 (29.1 %)	2.55 (1.12, 3.97)	2.5	5
Snoring	No	21 (26.6 %)	Reference	–	–
	Yes	58 (73.4 %)	1.48 (0.39, 2.57)	1.5	3
Apnoea	No	40 (50.6 %)	Reference	–	–
	Yes	39 (49.4 %)	0.57 (−0.33, 1.47)	0.5	1
Morning tiredness	No	13 (16.5 %)	Reference	–	–
	Yes	66 (83.5 %)	0.4 (−0.8, 1.59)	0.5	1
Daytime sleepiness	No	36 (45.6 %)	Reference	–	–
	Yes	43 (54.4 %)	0.12 (−0.77, 1.01)	0.5	1
HTN, Depression, Diabetes, Heart disease	No	46 (58.2 %)	Reference	–	–
	Yes	33 (41.8 %)	0.43 (−0.48, 1.34)	0.5	1

Abbreviations: BMI, Body mass index; HTN, hypertension.

correlation with the ESS score ($R^2 = 0.157$, $p = 0.487$), though it did show a moderate correlation with the Berlin questionnaire risk categorisation ($R^2 = 0.497$, $p < 0.001$) and the OSA-50 ($R^2 = 0.724$, $p < 0.001$), and a strong correlation with the total STOP-Bang score ($R^2 = 0.825$, $p < 0.001$). The three-group categorisation of the GPSS and STOP-Bang retained a significant though attenuated pairwise correlation compared to the total scores of each (Table 2). Considering the GPSS as a binary determiner with a moderate risk score (score >7), there was no agreement with an ESS binary score (Kappa −0.009), fair agreement with Berlin questionnaire and STOP-Bang high risk scores (Kappa's 0.344 & 0.214 respectively), and moderate agreement with STOP-Bang moderate risk score (Kappa 0.574) (Table 3). However, when considering the GPSS high risk score (score >13), there was substantial agreement with the STOP-Bang high risk score (Kappa 0.635). Notably, two patients were considered a low risk by the STOP-Bang, and yet a high risk by the GPSS, of which one had OSA. Of the six patients classed moderate risk by STOP-Bang and low risk by GPSS, none had OSA.

In the total cohort, the GPSS total score significantly outperformed the ESS, Berlin questionnaire and the OSA-50 for the prediction of OSA (Table 4, Fig. 2). The GPSS also showed slightly greater accuracy than the STOP-Bang, though the difference was not statistically significant. Notably the GPSS three-group categorisation retained 100 % sensitivity when classifying patients as moderate or severe risk across each cohort.

A significantly greater proportion of patients would meet the criteria for referral to further testing via sleep study (PSG) if the GPSS criteria were utilised compared to any other screening tool (Table 5). Among those patients referred, there would be no significant difference in the frequency of patients not having OSA by referral route. Among those patients who were not referred however, there would be a significant difference in the frequency of OSA, as 0 % of patients potentially not referred by the GPSS would have OSA, compared to 50–54 % of patients potentially not referred by utilising other questionnaires.

4. Discussion

This study demonstrates that the proposed GPSS screening tool (illustrated in Fig. 3) is able to predict the presence of OSA among at risk patients and could be of value for use in GP settings. The performance of the GPSS tool was significantly better than the existing ESS, Berlin questionnaire and the OSA-50 for predicting the presence of moderate severity OSA. Although the STOP-Bang tool performance was similar to the GPSS tool, a score of moderate or severe with the GPSS tool showed 100 % sensitivity, compared to 94.8 % for the STOP-Bang. Notably however, the GPSS tended to categorise patients as a higher risk than the STOP-Bang, with 12 of the 28 patients defined as low-risk by the STOP-Bang categorised as moderate or high-risk by the GPSS (of whom 5 (41.7 %) had OSA), and 18 of the 63 patients defined as moderate-risk by the STOP-Bang categorised as high-risk by the GPSS (of whom 14 (77.8 %) had OSA).

Over the past several decades there have been efforts to establish comprehensive screening tools to better identify at risk patients with

Table 2
Risk group categorisation of the GPSS and the STOP-Bang showing the number in each category, and within parenthesis the number (percentage) of those who had OSA.

Risk Assessment		GPSS score		
	Risk	Low risk ($n = 22$)	Moderate risk ($n = 58$)	High risk ($n = 79$)
STOP-Bang	Low risk ($n = 28$)	16 (0 (0 %))	10 (4 (40 %))	2 (1 (50 %))
	Moderate risk ($n = 63$)	6 (0 (0 %))	39 (20 (51.3 %))	18 (14 (77.8 %))
	High risk ($n = 68$)	0 (0 (0 %))	9 (6 (66.7 %))	59 (51 (86.4 %))

Abbreviations: GPSS, General practice sleep scale.

Table 3
Cohens Kappa showing agreement between GPSS and alternate questionnaires across risk categories.

	GPSS score					
	GPSS >7	p-value	GPSS >13	p-value	(low/mod/high)	p-value
ESS ≥8	−0.009	0.563	0.195	0.007*		
Berlin (n = 127) (high risk)	0.344	<0.001*	0.416	<0.001*		
OSA 50 ≥ 5 (n = 128)	0.480	<0.001*	0.421	<0.001*		
STOP-Bang (low/mod/high)					0.543	<0.001*
STOP-Bang ≥3	0.574	<0.001*	0.299	<0.001*		
STOP-Bang ≥5	0.214	<0.001*	0.635	<0.001*		

* Indicates p-value <0.05.
Abbreviations: ESS, Epworth sleepiness scale; OSA, Obstructive sleep apnoea; GPSS, General practice sleep scale.

Table 4
AUC ROCs, sensitivity and specificity for the ESS, Berlin questionnaire, OSA-50, STOP-Bang and GPSS for the total cohort.

Sleep assessment tools	AUC	Sensitivity	Specificity	PPV	NPV
ESS (continuous)	0.545 (0.454, 0.637)	–	–	–	–
ESS ≥8	0.559 (0.480, 0.639)	53.1 %	58.7 %	66.2 %	45.1 %
Berlin (n = 127) (high risk)	0.590 (0.505, 0.675)	74 %	44 %	67.1 %	52.4 %
OSA 50 (n = 128)	0.729 (0.641, 0.817)	–	–	–	–
OSA 50 ≥ 5	0.700 (0.620, 0.779)	85.9 %	54 %	74.4 %	71.1 %
STOP-Bang (continuous)	0.783 (0.710, 0.855)	–	–	–	–
STOP-Bang (low/mod/high)	0.762 (0.692, 0.833)	–	–	–	–
STOP-Bang ≥3	0.657 (0.593, 0.721)	94.8 %	36.5 %	69.5 %	82.1 %
STOP-Bang ≥5	0.710 (0.641, 0.778)	59.4 %	82.5 %	83.8 %	57.1 %
GPSS (continuous)	0.812 (0.744, 0.881)	–	–	–	–
GPSS (low/mod/high)	0.795 (0.728, 0.862)	–	–	–	–
GPSS >7	0.675 (0.615, 0.734)	100 %	34.9 %	70.1 %	100 %
GPSS >13	0.741 (0.672, 0.809)	68.8 %	79.4 %	83.5 %	62.5 %

Abbreviations: AUC, Area under the curve; ESS, Epworth sleepiness scale; GPSS, General practice sleep scale; OSA, Obstructive sleep apnoea; ROC, Receiver operator characteristic; PPV, Positive predictive value; NPV, Negative predictive value.

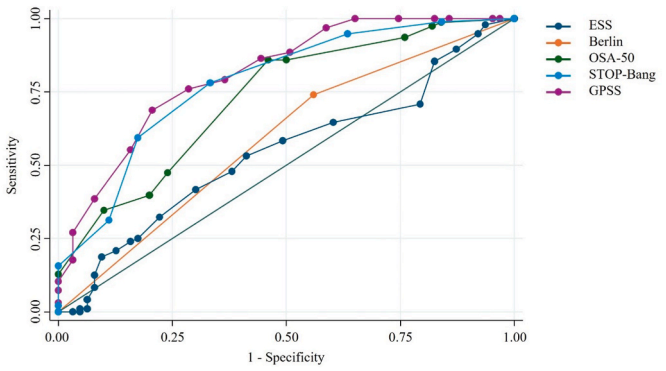


Fig. 2. AUC ROCs for the ESS, Berlin questionnaire, OSA-50, STOP-Bang and GPSS in our total cohort.
Abbreviations: AUC, Area under the curve; ESS, Epworth sleepiness scale; GPSS, General practice sleep scale; OSA, Obstructive sleep apnoea; ROC, Receiver operator characteristic.

Table 5
Comparison of proportion of patients with **OSA** by referral method.

OSA Screening tools	Referred	Referred and do not have OSA	Not referred	Not referred and have OSA
STOP-Bang (n = 159)	65 (40.9 %)*	16 (24.6 %)	94 (59.1 %)	47 (50 %)*
OSA-50 (n = 127)	43 (33.6 %)*	9 (20.9 %)	85 (66.4 %)	44 (51.8 %)*
Berlin questionnaire (n = 128)	49 (38.6 %)*	14 (28.6 %)	78 (61.4 %)	42 (53.8 %)*
Any questionnaire (n = 159)	70 (44 %)*	19 (27.1 %)	89 (56 %)	45 (50.6 %)*
GPSS >7 (n = 159)	137 (86.2 %)	41 (29.9 %)	22 (13.8 %)	0 (0 %)

Abbreviations: GPSS, General practice sleep scale; OSA, Obstructive sleep apnoea.
* indicates significant difference in proportions to the GPSS at $p < 0.05$.
Referred indicates a referral for a sleep study (polysomnography) testing.

sleep disorders, not only limited to OSA [46,47]. These screening tools have varied in the parameters that have been utilised and, in some cases, more than 175 clinical parameters have been suggested for assessment of sleep disorders [48,49]. Previous studies have demonstrated that despite easy access to well established OSA screening tools (ESS, STOP-Bang, Berlin questionnaire), primary care providers (GPs) do not routinely screen, assess, or refer to sleep specialist services for further assessments [50,51]. However, it is imperative to understand that GPs often encounter patients with complex medical issues in day-to-day clinical practice and moreover, are impeded by time constraints restricting their ability to implement any of the multiple or complex OSA screening tools [52,53]. In the year 2023, 80.8 % of GP attendances were 6–20-min consultations, highlighting that the time taken to fill multiple questionnaires within a consultation is likely a significant barrier to assess for OSA, let alone to further initiate specialist referrals or to undergo a sleep study (PSG), especially alongside other competing complex medical co-morbidities [54]. Hence, it is reasonable to speculate that a simplified sleep screening tool such as the proposed GPSS tool may be more accessible, by creating synergy between the patient and primary care provider, as this tool may be completed by the patient in the waiting room, and thereby trigger further investigations for the presence of OSA in at risk patients.

The current referral guidelines in Australia require a patient to demonstrate moderate–severe OSA on screening questionnaire via an ESS score ≥8 and either STOP-Bang ≥3, OSA-50 ≥ 5, or 'high risk' on the Berlin questionnaire [45]. In our analysis however, by utilising these criteria, more than 50 % of those patients who did not meet the referral criteria recorded OSA on PSG. It is likely that this is mainly due to the ESS threshold not being met, as we showed the ESS was the poorest predictor for OSA in this population. However, the STOP-Bang, which was the best performing tool apart from the GPSS, also tended to underestimate the risk for OSA. In light of the recognised potential for underdiagnosis of OSA, and the health sequalae that may follow [6, 23–25], this suggests that new referral guidelines for PSGs should be considered. The proposed GPSS tool is specifically designed to capture the most relevant data in the risk assessment for the presence of OSA. Moreover, it is simple to understand and is designed in such a way that patients can answer almost all questions by themselves, and it can be administered by practice clinical nurse consultant or medical administration staff member prior to consultation with their primary health practitioner.

Previous studies have found that the sensitivity and specificity of questionnaires to be quite variable depending on the population, with the STOP-Bang showing 94 & 32 %, the Berlin Questionnaire (≥3) 82 & 39 %, the OSA-50 95 & 51 %, and the TESS (≥3) 84 & 38 % respectively [11,12]. In the current study, the Berlin Questionnaire and OSA-50 showed significantly reduced accuracy in comparison to the STOP-Bang and the GPSS, highlighting that their validity depends upon their deployment and use within the right population context and setting. This includes both patient demographics, and their environment. In the current setting the lower accuracy of the STOP-Bang is likely due to the relatively younger age, and lower BMI from our study population, with the median for both being below the threshold for a score according to the STOP-Bang. This highlights that in younger and less obese populations, where OSA may be more likely underlined by comorbidities and deeper complex pathophysiology compared to just a higher body mass, the STOP-Bang may underperform. Furthermore, in the current study's external environment, there are relatively low levels of noise pollution, light pollution and ambient air pollution, and due to the latitude, the temperature and daytime light hours are relatively consistent across the year. These factors are not routinely considered within screening questionnaires, however they have all been shown to correlate with daytime sleepiness, and may thus influence and bias results of screening questionnaires [55–58].

In the current study, OSA was defined as an AHI of at least 15 which reduced the specificity of the GPSS. However, patients with an AHI of >5 may also benefit from referral and treatment – especially in the context of cardiorespiratory comorbidities. Of those 41 patients in the current study who did not have an AHI >15, 32 (78 %) had an AHI >5, and thus may warrant some form of treatment anyway. Furthermore, in the GP setting, the GPSS is designed to start a conversation and thinking about potential sleep health issues. It is up to the GP to use clinical reasoning in addition to the screening tool, incorporating fuller knowledge of the patients' medical conditions, lifestyle and symptoms to refer patients for further assessment. Identifying where the risk score comes from on the GPSS for the patient is vital to appropriate referral and treatment options i.e. a high BMI and neck circumference yet no signs, symptoms or comorbidities compared to a low BMI, young age, low neck circumference and presence of signs, symptoms and comorbidities. Nevertheless, this study has demonstrated that this simplified "GPSS" screening tool could be adopted in primary care and GP settings (Supplementary file 3 and 4). However, further prospective studies are warranted in a wider population setting to assess the applicability and the validity of the proposed GPSS tool.

5. Limitation

The GPSS tool was assessed in a population from the NT of Australia. Hence, the applicability in other population setting is not known. In this retrospective study only 159 consecutive patients were included. Although it may reflect a random sample population, it is unclear if the outcomes represented have sufficient scope for further population wide

GENERAL PRACTICE SLEEP SCALE

Name		
Address (optional)		
Phone (optional)		
Gender/Sex:	Height:	Weight:

Female score 0, Male score 2

1. **What is your age?**

	☐ 34 years or younger	☐ 35 to 45 years	☐ More than 45 years
Score	0	1	3

2. **What is your Body Mass Index (BMI)?**

	☐ Less than 25	☐25 to 30	☐30 to 40	☐ More than 40
Score	0	1	2	5

3. **What is your Neck circumference or Collar size?**

Female	☐ 35.5cm or less	☐35.5 to 38 cm	☐ More than 38 cm
Male	☐ 39.5cm or less	☐39.5 to 46 cm	☐ More than 46 cm
Score	0	4	5

Answer yes or no to the following questions. Once you have answered all questions, tally the number of questions you marked 'yes' to and write your score below.

4. **Do you snore loudly? Does your partner complain of your snoring – does it disturb others?**

	☐Yes	☐No
Score	3	0

5. **Has anyone ever seen you stop breathing, choking or gasping for air in you sleep?**

	☐Yes	☐No
Score	1	0

6. **Do you awake tired of unrefreshed in the morning?**

	☐Yes	☐No
Score	1	0

7. **Do you fall asleep easily (e.g. during meetings, watching TV etc.)**

	☐Yes	☐No
Score	1	0

8. **Do you suffer from high blood pressure, diabetes, heart disease, or Depression?**

	☐Yes	☐No
Score	1	0

TOTAL: _____

If the score is more than 7, further discussion needs to be considered for investigations and management strategies if appropriate

Fig. 3. The GPSS screening tool
[Electronic version available for use at: www.darwinsleephealth.com.au and https://darwinsleephealth.netlify.app/]
Abbreviations: GPSS, General practice sleep scale.

generalisation. Moreover, there could be bias, as the study participants were inclusive of referred patients attending the respiratory and sleep clinic appointments with potential high index for presence of OSA.

6. Conclusion

The proposed simple GPSS represented in this study can potentially be used as a standalone tool or complement other established screening tools in assessing at risk patients with OSA. It showed the greatest

accuracy for predicting OSA in this cohort and may offer greater ease of use and efficiency in the initial screening for high risk OSA patients amongst the general population. Further prospective research is warranted to test the applicability and adaptability of the GPSS tool in wider population settings.

CRediT authorship contribution statement

Timothy Howarth: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joe Hedger:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Winnie Chen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Himanshu Garg:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Conceptualization. **Subash S. Heraganahally:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Funding details

Nil.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We thank all staff at the DRSH/DPH centre, including sleep technologists, in particular Mr Jessie Crespo and Ms Ara J Perez for their contribution. We also extend our sincere apparitions to Dr Dayna Duncan for critical review of this paper and Dr Asanga Abeyaratne for helping with the electronic forms.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2024.11.022.

References

[1] Senaratna CV, Perret JL, Lodge CJ, Lowe AJ, Campbell BE, Matheson MC, Dharmage SC. Prevalence of obstructive sleep apnea in the general population: a systematic review. Sleep Med Rev 2017;34:70–81.
[2] Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328(17):1230–5.
[3] Adams RJ, Appleton SL, Taylor AW, Gill TK, Lang C, McEvoy RD, Antic NA. Sleep health of Australian adults in 2016: results of the 2016 Sleep Health Foundation national survey. Sleep Health 2017;3(1):35–42. https://doi.org/10.1016/j.sleh.2016.11.005.
[4] Appleton SL, Gill TK, Lang CJ, Taylor AW, McEvoy RD, Stocks NP, González-Chica DA, Adams RJ. Prevalence and comorbidity of sleep conditions in Australian adults: 2016 Sleep Health Foundation national survey. Sleep Health 2018;4(1):13–9. https://doi.org/10.1016/j.sleh.2017.10.006.
[5] Kee K, Naughton MT. Aust Fam Physician 2009;38(5):284–8.
[6] Senaratna CV, Perret JL, Lowe A, Bowatte G, Abramson MJ, Thompson B, Lodge C, Russell M, Hamilton GS, Dharmage SC. Detecting sleep apnoea syndrome in primary care with screening questionnaires and the Epworth sleepiness scale. Med J Aust 2019;211(2):65–70. https://doi.org/10.5694/mja2.50145.
[7] Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA 2004;291(16):2013–6. https://doi.org/10.1001/jama.291.16.2013.
[8] Johns M. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14:540–5.
[9] Chung F, Abdullah HR, Liao P. STOP-bang questionnaire: a practical approach to screen for obstructive sleep apnea. Chest 2016;149:631–8.
[10] Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. Ann Intern Med 1999;131:485–91.
[11] Hamilton GS, Chai-Coetzer C. Update on the assessment and investigation of adult obstructive sleep apnoea. AJGP 2019;48:176–81.
[12] Benn E, Wirth H, Short T, Howarth T, Heraganahally SS. The Top End sleepiness scale (TESS): a new tool to assess subjective daytime sleepiness among indigenous Australian adults. Nat Sci Sleep 2021 Mar 4;13:315–28. https://doi.org/10.2147/NSS.S298409.
[13] Onat A, Hergenç G, Yüksel H, Can G, Ayhan E, Kaya Z, Dursunoğlu D. Neck circumference as a measure of central obesity: associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. Clin Nutr 2009;28(1):46–51. https://doi.org/10.1016/j.clnu.2008.10.006.
[14] Mou J, Pflugeisen BM, Crick BA, Amoroso PJ, Harmon KT, Tarnoczy SF, Shirley Ho S, Mebust KA. The discriminative power of STOP-Bang as a screening tool for suspected obstructive sleep apnea in clinically referred patients: considering gender differences. Sleep Breath 2019;23(1):65–75. https://doi.org/10.1007/s11325-018-1658-y.
[15] Asha'ari ZA, Hasmoni MH, Ab Rahman J, Yusof RA, Ahmad RA. The association between sleep apnea and young adults with hypertension. Laryngoscope 2012;122(10):2337–42. https://doi.org/10.1002/lary.23379.
[16] Heraganahally SS, Zaw KK, Tip S, Jing X, Mingi JJ, Howarth T, Roy A, Falhammar H, Sajkov D. Obstructive sleep apnoea and adherence to continuous positive airway therapy among Australian women. Int Med J 2022;52(3):440–50. https://doi.org/10.1111/imj.15076. doi.org/.
[17] Chiu HY, Chen PY, Chuang LP, Chen NH, Tu YK, Hsieh YJ, Wang YC, Guilleminault C. Diagnostic accuracy of the Berlin questionnaire, STOP-BANG, STOP, and Epworth sleepiness scale in detecting obstructive sleep apnea: a bivariate meta-analysis. Sleep Med Rev 2017;36:57–70. https://doi.org/10.1016/j.smrv.2016.10.004.
[18] Senaratna CV, Perret JL, Matheson MC, Lodge CJ, Lowe AJ, Cassim R, Russell MA, Burgess JA, Hamilton GS, Dharmage SC. Validity of the Berlin questionnaire in detecting obstructive sleep apnea: a systematic review and meta-analysis. Sleep Med Rev 2017;36:116–24. https://doi.org/10.1016/j.smrv.2017.04.001.
[19] Oktay Arslan B, Uçar Hoşgör ZZ, Orman MN. Which screening questionnaire is best for predicting obstructive sleep apnea in the sleep clinic population considering age, gender, and comorbidities? Turk Thorac J 2020;21(6):383–9. https://doi.org/10.5152/TurkThoracJ.2019.19024.
[20] Kim B, Lee EM, Chung YS, Kim WS, Lee SA. The utility of three screening questionnaires for obstructive sleep apnea in a sleep clinic setting. Yonsei Med J 2015;56(3):684–90. https://doi.org/10.3349/ymj.2015.56.3.684.
[21] Silva GE, Vana KD, Goodwin JL, Sherrill DL, Quan SF. Identification of patients with sleep disordered breathing: comparing the Four-Variable screening tool, STOP, STOP-Bang, and Epworth Sleepiness Scales. J Clin Sleep Med 2011;7(5):467–72.
[22] Firat H, Yuceege M, Demir A, Ardic S. Comparison of four established questionnaires to identify highway bus drivers at risk for obstructive sleep apnea in Turkey. Sleep Biol Rhythm 2012;10:231–6. https://doi.org/10.1111/j.1479-8425.2012.00566.x. doi.org/.
[23] Young T, Palta M, Dempsey J, Peppard PE, Nieto FJ, Hla KM. Burden of sleep apnea: rationale, design, and major findings of the Wisconsin Sleep Cohort study. Wis Med J 2009;108(5):246–9.
[24] Grivell N, Haycock J, Redman A, Vakulin A, Zwar N, Stocks N, Frank O, Reed R, Chai- Coetzer CL, Grunstein RR, Doug McEvoy RD, Hoon E. Assessment, referral and management of obstructive sleep apnea by Australian general practitioners: a qualitative analysis. BMC Health Serv Res 2021;21:1248. https://doi.org/10.1186/s12913-021-07274-7. doi.org/.
[25] Marshall NS, Wong KK, Cullen SR, Knuiman MW, Grunstein RR. Sleep apnea and 20-year follow-up for all-cause mortality, stroke, and cancer incidence and mortality in the Busselton Health Study cohort. J Clin Sleep Med 2014;10(4):355–62. https://doi.org/10.5664/jcsm.3600.
[26] Hillman DR, Murphy AS, Antic R, Pezzullo L. The economic cost of sleep disorders. Sleep 2006;29(3):299–305.
[27] Martínez-García MA, Capote F, Campos-Rodríguez F, Lloberes P, Díaz de Atauri MJ, Somoza M, Masa JF, González M, Sacristán L, Barbé F, Durán-Cantolla J, Aizpuru F, Mañas E, Barreiro B, Mosteiro M, Cebrián JJ, de la Peña M, García-Río F, Maimó A, Zapater J, Hernández C, Grau SanMarti N, Montserrat JM, Spanish Sleep Network. Effect of CPAP on blood pressure in patients with obstructive sleep apnea and resistant hypertension: the HIPARCO randomized clinical trial. JAMA 2013;310(22):2407–15. https://doi.org/10.1001/jama.2013.281250.
[28] Cunningham J, Hunter M, Budgeon C, Murray k, Knuiman M, Hui J, Hillman D, Singh B, James A. The prevalence and comorbidities of obstructive sleep apnea in middle-aged men and women: the Busselton Healthy Ageing Study. J Clin Sleep Med 2021;17(10):2029–39.
[29] Heraganahally SS, Kruavit A, Oguoma VM, Gokula C, Mehra S, Judge D, Sajkov D. Sleep apnoea among Australian aboriginal and non- aboriginal patients in the northern territory of Australia– a comparative study. Sleep 2020;43(3):zsz248. https://doi.org/10.1093/sleep/zsz248.
[30] Heraganahally SS, Rajaratnam B, Silva SAAS, Robinson N, Oguoma VM, Naing P, Kangaharan N, Ilton M. Obstructive sleep apnoea and cardiac disease among aboriginal patients in the northern territory of Australia. Heart Lung Circ 2021;S1443–9506(21). https://doi.org/10.1016/j.hlc.2021.01.007. 44-5.

[31] Mehra S, Ghimire RH, Joy J, Mingi JJ, Hatch M, Garg H, Adams R, Heraganahally SS. Gender differences in the clinical and polysomnographic characteristics among Australian aboriginal patients with obstructive sleep apnea. Nat Sci Sleep 2020;12:593–602.
[32] Garg H, Er XY, Howarth T, Heraganahally SS. Positional sleep apnea among regional and remote Australian population and simulated positional treatment effects. Nat Sci Sleep 2020;12:1123–35.
[33] LaGrappe D, Massey L, Kruavit A, Howarth T, Lalar G, Daniels B, Wunungmurr JG, Flavell K, Barker R, Flavell H, Heraganahally SS. Sleep disorders among Aboriginal Australians with Machado-Joseph Disease: quantitative results from a multiple methods study to assess the experience of people living with the disease and their caregivers. Neurobiol Sleep Circadian Rhythms 2022. https://doi.org/10.1016/j.nbscr.2022.100075. doi.org/.
[34] Heraganahally SS, Howarth TP, Perez AJ, Crespo J, Atos CB, Cluney BJ, Ford LF. Acceptability, adaptability and adherence to CPAP therapy among Aboriginal Australians with OSA - "The A5 study". Sleep Med 2023;102:147–56.
[35] Heraganahally SS, Kerslake C, Issac S, Mingi JJ, Thomas I, Jayaram L, Adams R. Outcome of public hospital-funded continuous positive airway therapy device for patients with obstructive sleep apnoea: an Australian perspective study. Sleep Vigilance 2020;4:195–204. https://doi.org/10.1007/s41782-020-00114-4.
[36] Lindfield M, Howarth TP, Perez AJ, Crespo J, Atos CB, Huang HCC, Heraganahally SS. Obstructive Sleep Apnoea in Aboriginal Australians: polysomnographic outcomes and symptom perception post-CPAP implementation. Sleep Advances 2023;4:1. https://doi.org/10.1093/sleepadvances/zpad015. doi.org/.
[37] Howarth TP, Gentin N, Reyes-Chicuellar N, Jonas C, Williamson B, Blecher G, Widger J, Heraganahally SS. Sleep quality and obstructive sleep apnoea in Indigenous and non-Indigenous Australian children. Sleep Med 2022;98:68–78. https://doi.org/10.1016/j.sleep.2022.06.014.
[38] Howarth TP, Heraganahally SS, Gentin N, Jonas C, Williamson B, Jing MX, Suresh S. Comparison of polysomnographic characteristics between low birthweight and normal birthweight children in the Northern Territory of Australia: a case-control study. Sleep Health 2022:1–7. https://doi.org/10.1016/j.sleh.2022.07.003.
[39] Kruavit A, Fox M, Pearson R, Heraganahally S. Chronic respiratory disease in the regional and remote population of the Northern Territory Top End: a perspective from the specialist respiratory outreach service. Aust J Rural Health 2017;25:275–84. https://doi.org/10.1111/ajr.12349.
[40] Heraganahally SS, White S. A cost-effective novel innovative Box (C-Box) to prevent cockroach infestation of continuous positive airway pressure equipment: a unique problem in northern tropical Australia. Am J Trop Med Hyg 2019;101:937–40.
[41] Gentin N, Howarth TP, Crossland G, Patel H, Jonas C, Blecher G, Widger J, Whybourne A, Heraganahally SS. Establishing a telehealth model addressing paediatric sleep health in remote and rural Northern Territory Australia: overcoming the distance barrier. J Paediatr Child Health 2024;60(6):212–21. https://doi.org/10.1111/jpc.16549.
[42] Heraganahally SS, Howarth TP, Wirth H, Short T, Benn E. Validity of the new "Top End sleepiness scale" (TESS) against the STOP-bang tool in predicting obstructive sleep apnoea among indigenous Australian adults. Int Med J 2021. https://doi.org/10.1111/imj.15633. doi.org/.
[43] The 2017-18 annual report for the department of health and the health services. Northern territory government 2018. Available from: Department of Health website: www.health.nt.gov.au; May 2024.
[44] Census | Australian bureau of statistics. census, https://www.abs.gov.au; May 2023.
[45] Chai-Coetzer CL, Hancock k. Diagnosis of obstructive sleep apnoea in primary care. Aust J Gen Pract 2024;53:358–62. https://doi.org/10.31128/AJGP-03-23-6740.
[46] Roth T, Zammit G, Kushida C, Doghramji K, Mathias SD, Wong JM, Buysse DJ. A new questionnaire to detect sleep disorders. Sleep Med 2002;3(2):99–108. https://doi.org/10.1016/s1389-9457(01)00131-9.
[47] Klingman KJ, Jungquist CR, Perlis ML. Questionnaires that screen for multiple sleep disorders. Sleep Med Rev 2017;32:37–44. https://doi.org/10.1016/j.smrv.2016.02.004.
[48] Biard K, De Koninck J, Douglass AB. Creation of a shortened version of the sleep disorders questionnaire (SDQ). PLoS One 2024;19(2):e0288216. https://doi.org/10.1371/journal.pone.0288216.
[49] Douglass AB, Bornstein R, Nino-Murcia G, Keenan S, Miles L, Zarcone Jr VP, Guilleminault C, Dement WC. The sleep disorders questionnaire. I: creation and multivariate structure of SDQ. Sleep 1994;17(2):160–7. https://doi.org/10.1093/sleep/17.2.160.
[50] Miller JN, Berger AM. Screening and assessment for obstructive sleep apnea in primary care. Sleep Med Rev 2016;29:41–51. https://doi.org/10.1016/j.smrv.2015.09.005.
[51] Ononye T, Nguyen K, Brewer E. Implementing protocol for obstructive sleep apnea screening in the primary care setting. Appl Nurs Res 2019;46:67–71. https://doi.org/10.1016/j.apnr.2019.02.005.
[52] Britt HC, Harrison CM, Miller GC, Knox SA. Prevalence and patterns of multimorbidity in Australia. Med J Aust 2008;189(2):72–7. https://doi.org/10.5694/j.1326-5377.2008.tb01919.x.
[53] Irving G, Neves AL, Dambha-Miller H, Oishi A, Tagashira H, Verho A, Holden J. International variations in primary care physician consultation time: a systematic review of 67 countries. BMJ Open 2017;7(10):e017902. https://doi.org/10.1136/bmjopen-2017-017902.
[54] Medicare Australia - Statistics - Division of General Practice Statistics. All divisions of general practice (999); A1 GP attendances. http://medicarestatistics.humanservices.gov.au/statistics/; 2024.
[55] Mattingly SM, Grover T, Martinez GJ, Aledavood T, Robles-Granda P, Nies K, Striegel A, Mark G. The effects of seasons and weather on sleep patterns measured through longitudinal multimodal sensing. npj Digit Med 2021;4(76). https://doi.org/10.1038/s41746-021-00435-2.
[56] Conte F, Malloggi S, Albinni B, Cerasuolo M, Ficca G, Giganti F. The role of environmental context in modulating subjective sleepiness and sleep quality in the elderly: a comparison between home-dwelling subjects and nursing home residents. Home health care management & practice 2020;32(2):81–6. https://doi.org/10.1177/1084822319883824.
[57] Liu J, Ghastine L, Um P, Rovit E, Wu T. Environmental exposures and sleep outcomes: a review of evidence, potential mechanisms, and implications. Environ Res 2021;196:110406. https://doi.org/10.1016/j.envres.2020.110406.
[58] Johnson DA, Billings ME, Hale L. Environmental determinants of insufficient sleep and sleep disorders: implications for population health. Curr Epidemiol Rep 2018;5(2):61–9. https://doi.org/10.1007/s40471-018-0139-y.