ORIGINAL CONTRIBUTION

Primary Care vs Specialist Sleep Center Management of Obstructive Sleep Apnea and Daytime Sleepiness and Quality of Life

A Randomized Trial

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Importance Due to increasing demand for sleep services, there has been growing interest in ambulatory models of care for patients with obstructive sleep apnea. With appropriate training and simplified management tools, primary care physicians are ideally positioned to take on a greater role in diagnosis and treatment.

Objective To compare the clinical efficacy and within-trial costs of a simplified model of diagnosis and care in primary care relative to that in specialist sleep centers.

Design, Setting, and Patients A randomized, controlled, noninferiority study involving 155 patients with obstructive sleep apnea that was treated at primary care practices (n=81) in metropolitan Adelaide, 3 rural regions of South Australia or at a university hospital sleep medicine center in Adelaide, Australia (n=74), between September 2008 and June 2010.

Interventions Primary care management of obstructive sleep apnea vs usual care in a specialist sleep center; both plans included continuous positive airway pressure, mandibular advancement splints, or conservative measures only.

Main Outcome and Measures The primary outcome was 6-month change in Epworth Sleepiness Scale (ESS) score, which ranges from 0 (no daytime sleepiness) to 24 points (high level of daytime sleepiness). The noninferiority margin was −2.0. Secondary outcomes included disease-specific and general quality of life measures, obstructive sleep apnea symptoms, adherence to using continuous positive airway pressure, patient satisfaction, and health care costs.

Results There were significant improvements in ESS scores from baseline to 6 months in both groups. In the primary care group, the mean baseline score of 12.8 decreased to 7.0 at 6 months ($P<.001$), and in the specialist group, the score decreased from a mean of 12.5 to 7.0 ($P<.001$). Primary care management was noninferior to specialist management with a mean change in ESS score of 5.8 vs 5.4 (adjusted difference, −0.13; lower bound of 1-sided 95% CI, −1.5; $P=.43$). There were no differences in secondary outcome measures between groups. Seventeen patients (21%) withdrew from the study in the primary care group vs 6 patients (8%) in the specialist group.

Conclusions and Relevance Among patients with obstructive sleep apnea, treatment under a primary care model compared with a specialist model did not result in worse sleepiness scores, suggesting that the 2 treatment modes may be comparable.

Trial Registration anzctr.org.au Identifier: ACTRN12608000514303

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OBSTRUCTIVE SLEEP APNEA with accompanying daytime sleepiness was estimated during the early 1990s to affect between 2% and 4% of middle-aged adults.[1,2] With growing awareness of the public health implications of untreated disease[3-6] and rising obesity rates that have increased the prevalence of obstructive sleep apnea,[7] there has been a steady demand for sleep service provision in specialist centers and growing waiting lists for sleep physician consultation and laboratory-based polysomnography (PSG). As a result, there has been increasing interest in the use of screening questionnaires, home sleep monitoring, and autotitrating continuous positive airway pressure (CPAP),[8-10] and greater involvement of other health care professionals in providing care.[11]

One-third of primary care patients report symptoms suggestive of obstructive sleep apnea.[12] With appropriate training and simplified management

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tools, primary care physicians and practice nurses might be ideally positioned to take on a greater role in diagnosis and management. Several randomized controlled studies have shown that ambulatory management of obstructive sleep apnea in specialist sleep centers using home testing and autotitrating CPAP produce comparable patient outcomes with standard laboratory-based sleep study methods.[8-11] However, whether an ambulatory approach would be noninferior in a primary care setting is unknown. The aim of this study was to compare the clinical efficacy of obstructive sleep apnea management provided by a primary care physician and community-based nurse with currently recommended management in a specialist sleep center.

METHODS

Design Overview

A randomized, controlled, noninferiority study was conducted to compare an ambulatory, primary care–based management strategy vs standard care in a specialist sleep center. The research protocol was approved by institutional research ethics committees at the Repatriation General Hospital and Flinders Medical Centre, South Australia, and the study was registered with the Australian New Zealand Clinical Trials Registry (ACTRN 12608000514303). Patients and primary care physicians provided written informed consent.

Settings and Participants

Patients aged 25 to 70 years attending a primary care consultation for any reason were screened for eligibility by 34 primary care physicians between September 2008 and June 2010. Participants were recruited from 4 geographical locations in South Australia: (1) metropolitan Adelaide (6 primary care practices, 2 community nurse clinics) and 3 rural regions, (2) South Coast (2 primary care practices, 1 community nurse clinic), (3) Barossa Valley (4 primary care practices and 1 community nurse clinic), and (4) Riverland (4 primary care practices and 1 community nurse clinic). All patients were screened for moderate to severe obstructive sleep apnea using a validated 2-step method[13] that consisted of a 4-item screening questionnaire which, if positive (ie, score ≥5 out of 10 points), was followed by overnight oximetry (ApneaLink, ReMed). Inclusion criteria were (1) high diagnostic likelihood of moderate to severe obstructive sleep apnea defined as a score of 5 or more on the questionnaire and an overnight 3% oxygen desaturation index (≥3% ODI) of at least 16 events per hour and (2) an Epworth Sleepiness Scale (ESS) score of 8 or higher or persistent hypertension despite taking 2 or more antihypertensive agents. The ESS subjectively assesses excessive daytime sleepiness by asking patients to rate their chance of dozing off from 0 (would never doze) to 3 (high chance of dozing) for 8 commonly encountered scenarios, for a total possible score of 24. A cut-off score of 8 or more suggests the presence of at least mild daytime sleepiness. Exclusion criteria were (1) severe morbid obesity (body mass index [BMI], calculated as weight in kilograms divided by height in meters squared, >50); (2) neuromuscular disease; (3) unstable psychiatric disease or cognitive impairment considered likely to interfere with adherence to instructions, completing the study or managing CPAP; (4) hospitalization in the previous 3 months for myocardial infarction, unstable angina, cardiac failure, or cerebrovascular accident or New York Heart Association class III or IV symptoms; or (5) lung disease with awake resting oxygen saturation of less than 92%. Demographic and anthropometric data were collected, including sex, age, geographical region, weight, height, BMI, and waist circumference.

Randomization and Interventions

Patients meeting eligibility criteria were randomized into either primary care management or specialist sleep center management. Randomization was conducted by a telephone call to a clinical trials pharmacist independent of the study, using a computer-generated random numbers list.

Primary Care Management. Patients' treatment was managed by primary care physicians and a community-based nurse who participated in a 6-hour education program on obstructive sleep apnea and its management. The education program was developed and presented by sleep physicians and a specialist nurse from the university hospital sleep medicine center and accredited by the Royal Australasian College of General Practitioners. Patients were reviewed in-person by 1 of 4 nurses who held clinics at 5 community locations (2 nurse clinics in metropolitan Adelaide and 1 in each of the 3 rural regions) to review progress and were given advice on managing CPAP-related adverse effects, encouraged to maintain adherence to therapy, advised to discuss alternative treatment options with primary care physicians if necessary, educated about lifestyle changes to improve obstructive sleep apnea, and asked to complete relevant research questionnaires. One nurse had 15 years of experience in a tertiary care sleep medicine service and at the 2 metropolitan-based clinics and at the South Coast clinic. The other 3 nurses were newly trained in obstructive sleep apnea management but had worked as rural-based practice nurses prior to their involvement (1 nurse cared for patients at the Barossa Valley clinic and the other 2 nurses cared for patients at the Riverland clinic). In addition to the 6-hour education program that they attended with the primary care physicians, the sleep training provided to the community-based nurses also involved 5 days of in-service training with specialist nurses at the tertiary sleep center. Home autotitrating CPAP (REMstar Auto, Respironics or S8 AutoSet Spirit, ResMed) was used over 3 consecutive nights to determine a fixed treatment pressure based on the 90th (REMstar Auto) or 95th (S8 AutoSet Spirit) percentile pressure. Continuous positive airway pressure devices were converted to a fixed pressure mode for the remainder of the study. Patients were followed up by their nurse with a telephone call within 2 weeks of commencing therapy and in person at months 1,

3, and 6. Primary care physician appointments were set for months 3 and 6. Adherence to CPAP was objectively recorded by each device. Data information cards were downloaded at 1-, 3-, and 6-month reviews. Although CPAP was considered the primary treatment, physicians could initially prescribe, or at a subsequent review, switch their patients to alternative therapies if deemed appropriate, including lifestyle measures, a mandibular advancement splint (MAS), or upper airway surgery. Physicians were provided with contact details of a dentist expert in the fashioning of MAS (SomnoDent MAS, SomnoMed Ltd). Continuous positive airway pressure and MAS were available at no charge to participants. Physicians were advised that a sleep physician could be contacted for advice or to request a formal consultation.

Specialist Sleep Centre Management. Patients were referred to 1 of 9 sleep specialists for ongoing management. Sleep specialists had completed their Fellowship of the Royal Australasian College of Physicians, having undertaken at least 3 years of respiratory medicine training including 1 year of full-time sleep-medicine training. Sleep specialists were provided with the patient's overnight oximetry trace. Further investigations, including full or split-night laboratory PSG, and treatment recommendations were left to the discretion of the treating physician. Continuous positive airway pressure titration, if recommended, was conducted manually during laboratory PSG or by home autotitration. Experienced nurses at the specialist center provided support for CPAP setup and education. The same models of CPAP machines were used as those in the primary care group. In-person follow-up visits occurred at the same time points as the primary care group.

Outcomes and Follow-Up

The primary outcome measure was the change in ESS score from baseline to 6 months.[14] Secondary outcome measures were the Functional Outcomes of Sleep Questionnaire (FOSQ),[15] Sleep Apnea Symptoms Questionnaire (SASQ),[16] Short-Form 36 Health Survey (SF-36)[17] vitality and mental health components, CPAP adherence, blood pressure, and weight, which were measured at baseline and 6 months. Vitality and mental health components of the SF-36 have been most responsive in previous CPAP studies[18,19]; therefore, only changes in these 2 scores are reported. A Visit-Specific Satisfaction Questionnaire (VSQ-9)[20] was also completed at 6 months. The eMethods includes a detailed description of the questionnaires (available at http:www.jama.com).

Statistical Analysis

Statistical analyses were performed using STATA/IC 11.2 for Windows (StataCorp LP). Missing values for the main outcome measures were replaced by multiple imputation with multivariate normal regression using demographic and baseline outcome data and with the creation of 10 complete data sets. Comparisons between groups for the mean change in ESS, FOSQ, SASQ, and SF-36 scores; weight; and blood pressure after 6 months were conducted in an intention-to-treat manner including all patients randomized using analysis of covariance with adjustment for baseline scores and region. Results for data analyzed by carrying forward baseline observations for missing values and by inclusion of patients with complete data have also been conducted as a sensitivity analysis. A *t* test was used to evaluate for group differences in CPAP use and VSQ-9 scores. The difference in the mean change in ESS scores after 6 months was evaluated for noninferiority of the primary care group using an a priori determined noninferiority margin of −2.0 based on past studies of minimal clinically important differences for health-related quality of life instruments,[21] clinical studies that have assessed natural variations in ESS scores and ESS responses to placebo CPAP in patients with obstructive sleep apnea,[22-24] and consensus among sleep physicians in a previously published study.[11] For the noninferiority analysis, significance testing using a 1-sided *P* value of .05 was used to determine the probability of rejecting the null hypothesis of inferiority. Statistical significance for secondary outcomes was determined using a 2-sided α of .05.

Sample Size

The study was powered to assess for noninferiority of the primary care group relative to the specialist group in the mean change in ESS score after 6 months. A sample size of 138 patients (69 patients in each group) was required for a study with 90% power and a type I error of 5%, assuming a noninferiority margin of −2.0 and a standard deviation of 4.0 for the change in ESS score. A total of 155 patients were recruited to allow for potential withdrawals and loss to follow-up.

Within-Trial Costs

Within-trial sleep diagnostic and treatment costs were collected and compared during the 6-month follow-up for nurse consultations, primary care physicians, and sleep physician consultations and for travel, sleep study, and treatment-related costs. Within-trial costs were also calculated for the US context and reported in US dollars. The eAppendix describes how costs were calculated.

RESULTS

A flow diagram outlining the recruitment and randomization pathway is shown in the FIGURE. In all, 402 patients were referred by primary care physicians after initial screening to community-based nurses for review of eligibility criteria and oximetry monitoring. Of those, 301 patients agreed to participate and were eligible for overnight oximetry. One hundred fifty-five patients were eligible and were randomized into the study.

Baseline Characteristics

Eighty-one patients (27 from Adelaide; 3, South Coast; 24, Barossa Valley; and 27, Riverland) were randomized to the primary care group and 74 patients (18 from Adelaide; 1, South Coast; 26, Barossa Valley; and 29, Riverland) to the specialist group. Both

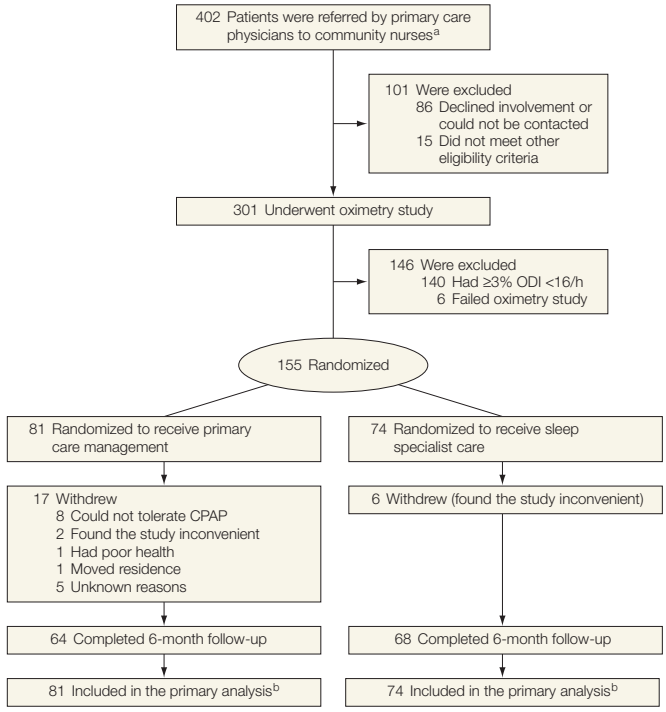
groups were comparable and consisted of predominantly middle-aged, obese men from rural regions with at least mild daytime sleepiness (TABLE 1).

Treatment

The principal treatments recommended to patients at baseline and used at 6 months are outlined in TABLE 2. At baseline, 90% of patients in the primary care group initiated CPAP, whereas 70% in the specialist group initiated CPAP with a higher proportion of patients being managed with conservative measures only. In the specialist group, 73 of 74 patients had a laboratory-based PSG: 38 for a full night and 35 for a split night. Three patients (4%) in the primary care group were referred for sleep specialist consultation during the study, 1 of whom had a laboratory full-night diagnostic PSG.

After 6 months' follow-up, the proportions of patients using CPAP were similar in both cohorts (63% in the primary care group; 61% in the specialist group). More patients withdrew from the study in the primary care group. Baseline demographic, anthropomorphic, and obstructive sleep apnea severity indices were similar in patients who withdrew and those who completed the study in each study group (eTable 1).

Figure. Flow Diagram of Participant Recruitment and Randomization



ODI indicates oxygen desaturation index; CPAP, continuous positive airway pressure.
[a] The total number of patients initially screened by primary care physicians for eligibility is unknown.
[b] Primary analysis was conducted in an intention-to-treat manner and missing values were replaced by multiple imputation.

Table 1. Baseline Characteristics of Patients[a]

	Primary Care (n = 81)	Specialist Sleep Center (n = 74)
Men, No. (%)	69 (85)	57 (77)
Age, mean (SD), y	57.2 (10.9)	54.5 (11.8)
Region, No. (%)		
Metropolitan	27 (33)	18 (24)
South Coast	3 (4)	1 (1)
Riverland	27 (33)	29 (39)
Barossa Valle	24 (30)	26 (35)
BMI, mean (SD)	33.1 (5.5)	33.7 (5.6)
Waist circumference, mean (SD), cm	111.2 (13.6)	113.1 (14.5)
OSA 50 questionnaire score, mean (SD)	8.2 (1.5)	8.1 (1.7)
ESS total score, mean (SD)	12.8 (3.9)	12.5 (3.9)
Oximetry ≥3% ODI, events/h	32.7 (18.2)	35.7 (17.4)

Abbreviations: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; ESS, Epworth Sleepiness Scale; ODI, oxygen desaturation index; OSA, obstructive sleep apnea.
[a] None of the differences between the study groups were statistically significant. Definitions of the score ranges and meanings are in the Methods section.

Outcomes

Daytime Sleepiness: ESS score. The mean ESS for the entire study population was 12.6 (95% CI, 12.0-13.3). The mean ESS scores in the primary care group improved from 12.8 at baseline to 7.0 at 6 months, for an adjusted mean difference of 5.8 (95% CI, 4.4-7.2; $P<.001$) and in the specialist group from a baseline mean of 12.5 to 7.0 at 6 months, for an adjusted mean difference of 5.4 (95% CI, 4.2-6.6; $P<.001$; TABLE 3). After controlling for baseline ESS score and region, the adjusted difference in the mean change in the ESS score was −0.13 (lower bound of 1-sided 95% CI, −1.5; $P=.43$). Sensitivity analyses using baseline observations carried forward for missing values and using data only from patients who completed the study produced similar outcomes. For the analysis using baseline observations carried forward for missing data, the adjusted difference in mean change in the ESS score was −0.63 (lower bound of 1-sided, 95% CI, −1.80; $P=.19$). When including only the 64 patients in the primary care group and the 68 in the specialist group who completed the study,

the adjusted difference in the mean change in the ESS score was −0.14 (lower bound of 1-sided 95% CI, −1.28; $P=.42$). These results support noninferiority of primary care management because the lower bounds of the 1-sided 95% CI for all analyses were greater than the prespecified noninferiority margin of −2.0.

Secondary Outcomes. Secondary outcomes measures are shown in TABLE 4. After 6 months, there were significant improvements in the mean FOSQ, SASQ, or SF-36 scores in both primary care and specialist groups compared with baseline ($P<.001$ for all measures), but no difference was evident between groups.

Adherence to CPAP use among those using it at 6 months was no different between the 2 groups, with mean (SD) usage of 4.8 (2.1) hours per night of the 51 patients in the primary care group and 5.4 (0.3) hours per night among the 44 patients in the specialist group ($P=.11$). No differences in systolic or diastolic blood pressure or weight were evident in either primary care or specialist groups after 6 months, and there was no difference in the mean change between groups. There were small, but statistically significant, differences in 5 out of 9 items in the VSQ-9 patient satisfaction survey in favor of the primary care group (eTable 2), although no difference in overall satisfaction was evident. Furthermore, effect sizes for the 9 items were small (range, 0.14-0.41) and may not therefore be clinically significant.

Table 2. Principal Treatment Recommended to Patients at Baseline and Used at 6 Months

	No. (%) of Patients	
	Primary Care (n = 81)	Specialist Sleep Center (n = 74)
Baseline recommended treatment		
Principal treatment		
CPAP	73 (90)	52 (70)
Conservative measures only	2 (2)	18 (24)
MAS	1 (1)	3 (4)
Patient withdrew	5 (7)	1 (1)
6-Month principal treatment		
No. of patients[a]	64	68
CPAP	51 (63)	45 (61)
Conservative measures only	7 (9)	12 (16)
MAS	6 (7)	11 (15)

Abbreviations: CPAP, continuous positive airway pressure; MAS, mandibular advancement splint.
[a] At 6 months, 17 patients had withdrawn from primary care group and 6 dropped out of the specialist group.

Table 3. Change in Epworth Sleepiness Scale Score at 6 Months

	Mean (95% CI)				
Epworth Sleepiness Scale Score	Primary Care (n = 81)	Specialist Sleep Center (n = 74)	*P* Value[b]	Adjusted Difference in Mean Change[a]	Lower Bound of 1-Sided 95% CI
Baseline	12.8 (12.0-13.6)	12.5 (12.4-13.5)			
6-mo[c]	7.0 (6.0-8.0)	7.0 (6.0-8.0)			
Change[d]	5.8 (4.4-7.2)	5.4 (4.2-6.6)	.43	−0.13	−1.50

Abbreviation: ESS, Epworth Sleepiness Scale.
[a] Based on analysis of covariance with adjustment for baseline ESS score and region.
[b] 1-Sided *P* value.
[c] Missing values replaced by multiple imputation.
[d] $P<.001$ for paired *t* test comparison of ESS examining change from baseline to 6 months.

Table 4. Secondary Outcome Measures at 6 Months

	Primary Care			Specialist Sleep Center				
		Mean (95% CI)			Mean (95% CI)			
	No. of Patients	Baseline Score	Change at 6 mo	No. of Patients	Baseline	Change at 6 mo	Adjusted Difference[a]	*P* Value
FOSQ[b]	81	14.7 (14.1 to 15.4)	2.8 (2.0 to 3.6)[c]	74	14.2 (13.5 to 14.8)	2.8 (2.2 to 3.4)[c]	0.18 (−0.58 to 0.94)	.64
SASQ[d]	81	71.2 (66.5 to 75.9)	−29.7 (−23.0 to −36.4)[c]	74	72.1 (67.4 to 76.7)	−31.2 (−23.8 to −38.6)[c]	0.78 (−7.22 to 8.78)	.85
SF-36[e]								
Vitality	81	43.6 (39.1 to 48.1)	16.1 (11.0 to 21.2)[c]	74	34.6 (30.3 to 38.9)	19.9 (14.4 to 25.4)[c]	2.51 (−3.88 to 8.90)	.44
Mental health	81	66.5 (62.4 to 70.7)	7.9 (4.0 to 11.8)[c]	74	61.6 (57.2 to 66.1)	8.4 (4.5 to 12.3)[c]	1.57 (−3.41 to 6.55)	.54
Blood pressure, mm Hg								
Systolic	81	134.0 (130.3 to 137.8)	−2.2 (−6.3 to 1.9)	74	135.9 (132.1 to 139.7)	−4.4 (−9.1 to 0.3)	1.52 (−4.14 to 7.18)	.60
Diastolic	81	84.5 (82.0 to 86.9)	−1.4 (−4.3 to 1.5)	74	85.23 (82.7 to 87.8)	−0.5 (−3.6 to 2.6)	−1.32 (−4.97 to 2.33)	.48
Weight, kg	81	101.9 (97.9 to 105.9)	−0.1 (−2.5 to 2.3)	74	103.2 (98.9 to 107.5)	0.3 (−1.5 to 2.1)	−0.43 (−3.43 to 2.57)	.78

Abbreviations: FOSQ, Functional Outcomes of Sleep Questionnaire; SASQ, Sleep Apnea Symptoms Questionnaire; SF-36, Short Form 36 Health Survey.
[a] Based on analysis of covariance with adjustment for baseline measure and region.
[b] Measures disease-specific quality of life by assessing the effect of daytime sleepiness on activities of daily living, total score out of a possible 20 points with higher scores indicating higher levels of functioning.
[c] $P<.001$ for paired *t* test comparison of outcome measures examining change from baseline to 6 months.
[d] Measures the frequency of 14 commonly reported obstructive sleep apnea symptoms on a 10-cm visual analog scale, total score out of a possible 140 points, with higher scores indicating greater severity of obstructive sleep apnea symptoms.
[e] Measures the general health status of a patient using 8 subscales, each of which have a total score out of a possible 100 points, with higher scores indicating a higher level of functioning. Only 2 of the 8 SF-36 subscales (ie, vitality and mental health) are reported herein.

Within-Trial Costs

Comparison of within-trial sleep diagnostic and treatment costs revealed a total average cost per randomized patient of A $1606.48 in the primary care group and A $2576.47 in the specialist group (eTable 3). When considered in the US context, the equivalent total average costs per patient were estimated at US $1819.44 in the primary care group and US $3067.86 in the specialist group. Sleep study costs, sleep physician consultations, and travel costs appeared to be the main contributors to the increased within-trial costs in the specialist group.

COMMENT

In this study, patients identified by a 2-step screening process as having a high likelihood of moderate to severe obstructive sleep apnea and who were at least mildly sleepy were randomized to either primary care or specialist care management. Clinically significant improvements in the primary outcome measure, daytime sleepiness, were observed following treatment in both settings and outcomes for patients managed in primary care were not inferior to those treated in a specialist center. No differences between groups were found in secondary outcomes, including change in obstructive sleep apnea symptoms, quality of life, CPAP adherence, and overall patient satisfaction.

These results extend the findings of previously published studies of ambulatory models of care for obstructive sleep apnea deployed in specialist sleep centers. Mulgrew et al[8] used a strategy of portable monitoring and autotitrating CPAP and found no differences in major outcomes, including change in ESS scores and quality of life compared with laboratory-based care. Furthermore, CPAP adherence was higher in the ambulatory care group. Berry et al[9] conducted a similar study in a veteran population in which patients with obstructive sleep apnea were randomized to either portable monitoring and autotitrating CPAP or to laboratory PSG and CPAP titration. After 6 weeks, no differences were observed in CPAP adherence, change in ESS or FOSQ scores, patient satisfaction with CPAP or residual AHI. Kuna et al[10] found that functional outcomes and CPAP adherence were not inferior to laboratory-based care when using an ambulatory strategy for obstructive sleep apnea. None of these studies assessed the relative costs of the simplified management strategies.

More recent studies evaluating ambulatory strategies have examined within-study costs. Andreu et al[25] randomized patients to either home sleep monitoring and follow-up, hospital PSG and follow-up, or home monitoring and hospital follow-up. They found no differences in CPAP adherence or in ESS, FOSQ, or symptom scores after 6 months. They also reported significant mean (SD) cost savings for home diagnosis and follow-up (€590 [€43]) and home diagnosis with hospital follow-up (€644[€93]) compared with laboratory PSG and hospital follow-up (€849 [€11]). Rosen et al[26] showed that home diagnosis and autotitrating CPAP was associated with higher adherence, similar to the study by Mulgrew et al, with no difference in the change in ESS scores or functional outcomes after 3 months compared with laboratory-based management. Within-trial costs were 25% less expensive for the home-treatment group.

We previously conducted a randomized controlled trial to evaluate a simplified model of care for obstructive sleep apnea led by sleep-trained nurses in a tertiary care setting.[11] The primary outcome, mean change in ESS scores at 3 months, for patients assigned to the nurse-led approach was not inferior to the specialist-led group and had within-study cost savings of A $1111 per patient. These results led us to consider the potential role of primary care physicians and nurses in the diagnosis and management of obstructive sleep apnea.

The present study, which recruited patients from metropolitan and rural communities, had a longer follow-up than previous studies (ie, 6 months vs 1-3 months). We believe that important elements in the success of the study were the training given to primary care physicians and nurses and access to specialist support. Thus, although primary care physicians and community nurses were encouraged to take primary responsibility for patient management, this simplified strategy was designed as a hub-and-spoke–like model of care, with a central specialist sleep center overseeing and supporting a number of primary care–based obstructive sleep apnea clinics. Of note however is that primary care physicians cross-referred only 3 of 81 patients (4%) to sleep specialists for a second opinion. This could be because two-thirds of the study population were recruited in rural regions located 90 to 240 km from the city-based specialist sleep service. However, only 1 out of 21 metropolitan-based patients (5%) enrolled in the primary care group were cross-referred suggesting perhaps that, at least in the context of the research study, primary care physicians and nurses were reasonably confident in their management decisions.

At baseline, CPAP was recommended more frequently in the primary care group. However, by 6 months a considerable number of patients in the primary care group had stopped using CPAP, and the proportion of patients using CPAP was similar to that in the specialist group. Average daily CPAP use at 6 months was no different between groups. These observations could suggest that specialists, who have additional information from laboratory PSG and are more experienced at obstructive sleep apnea management, may be better at predicting which patients will adhere to CPAP in the long term. Alternatively, attendance at a specialist or nurse review, or both in a tertiary sleep center may itself have had an influence on long-term adherence. There could also be an effect of experience such that with time, the primary care physicians may become more confident with managing sleep apnea and thus promote greater CPAP adherence or recommend alternative therapies such as a MAS or conservative measures earlier in the course of treatment for patients who are reluctant to use or are intolerant of CPAP. However, in

spite of the different approaches to management, patient outcomes were ultimately similar in both groups.

Analysis of within-trial sleep-related diagnostic and treatment costs revealed that primary care management of obstructive sleep apnea was approximately 40% cheaper than specialist care in both the Australian and US contexts. However, our study reports within-trial sleep management-related costs only and not indirect costs nor does it assess the longer-term economic implications of an ambulatory strategy in primary care. Recent debate has resulted from a study by Pietzsch et al[27] that showed full-night PSG to be more cost-effective than unattended home monitoring in the management of obstructive sleep apnea because of its superior diagnostic accuracy. It was pointed out in an accompanying editorial,[28] however, that several assumptions used in their modeling could have magnified the effects of false-positive and false-negative results and elevated the costs of portable monitoring. More detailed cost-effectiveness analyses that account for increased access and reduced waiting lists, the impact of false-positive and false-negative tests, potential adverse health consequences of untreated disease and benefits of therapy, and indirect costs of ambulatory, primary care–based management strategies for obstructive sleep apnea are needed.

Several limitations of our study are acknowledged. We excluded patients with a BMI higher than 50, significant respiratory or cardiac disease, and serious psychiatric illness or cognitive impairment. Thus, the results of this study cannot be generalized to these populations. It is possible that patients with predominantly central sleep apnea, including Cheynes Stokes respiration, may have been misdiagnosed in the primary care group, because only oximetry was used to identify patients with disease. However, we excluded patients with disorders prone to central sleep apnea (eg, heart failure) plus residual AHI was monitored on CPAP devices and, at 6 months, only 1 patient in the primary care group had a residual AHI exceeding 15/h.

One of the community-based nurses assigned to the primary care group who predominantly managed patients in the metropolitan region had 15 years of experience in a tertiary care sleep medicine service, whereas the other 3 rural-based community nurses were newly trained in obstructive sleep apnea management. The more experienced nurse was included in the primary care group to assist in the training and to mentor the newly recruited nurses. We would anticipate that if such a model of care were to be translated into real practice, some nurses employed to care for patients with obstructive sleep apnea in a community-based clinic would likely have some prior experience in obstructive sleep apnea management, particularly in the metropolitan region where there is a larger pool of experienced, CPAP-trained nursing staff. The more experienced nurse cared for a total of 30 patients (37%) in the primary care group based in the metropolitan and rural South Coast regions, while the 3 less experienced nurses cared for the other 51 patients (63%) patients located in the rural Barossa Valley and Riverland regions.

We have attempted to account for the difference in nurse experience by adjusting for geographical region in addition to baseline ESS score in our analyses. Furthermore, withdrawal rates, change in ESS scores from baseline to 6 months, 6-month CPAP adherence, and auto-CPAP titration results were not significantly different between the experienced vs newly trained nurses. Therefore, we do not believe that inclusion of an experienced nurse in the primary care group significantly biased our results.

For reasons that are not entirely clear, more patients withdrew from the primary care group. It is possible that patients were more inclined to remain in the study if they were receiving specialist consultations. Alternatively, participants may have had less faith in the advice of the primary care team and the greater number of withdrawals may be because physicians were less skilled in educating patients about obstructive sleep apnea and treatment options. Although overall patient satisfaction was no different between groups, the opinions of patients who withdrew were not sampled. Interestingly, one-half of patients who withdrew from the primary care group did so because of CPAP intolerance; whereas this was not cited as a reason in the specialist group. The higher number of withdrawals in the primary care group may have biased study results by excluding data from patients with worse outcomes. However, we believe our findings are robust because in both the primary analysis using multiple imputation for missing values and in 2 sensitivity analyses, patient outcomes in the primary care group remained clinically noninferior.

In conclusion, in this randomized controlled study, a simplified management strategy for obstructive sleep apnea based in primary care was not clinically inferior to standard care in a specialist sleep center. It possibly could be delivered at a lower cost. Thus, with adequate training of primary care physicians and practice nurses and with appropriate funding models to support an ambulatory strategy, primary care management of obstructive sleep apnea has the potential to improve patient access to sleep services. This would be particularly beneficial for rural and remote regions, as well as developing nations, where access to specialist services can be limited. However, some caution needs to be exercised in extrapolating these findings to actual practice in which primary care physicians may not be as skilled and motivated as those who participated in this randomized controlled trial and in which patient outcomes may not be as good as those observed in this study. Our comparison of within-trial costs cannot be considered a cost-effectiveness analysis, and further investigation is needed in this regard.

Author Contributions: Dr Chai-Coetzer had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: All authors.
Acquisition of data: Chai-Coetzer, Antic, Rowland, Catcheside, McEvoy.
Analysis and interpretation of data: Chai-Coetzer, Antic, Esterman, Catcheside, Eckermann, McEvoy.

Drafting of the manuscript: Chai-Coetzer, Antic, Eckermann, McEvoy.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Chai-Coetzer, Estermann, Catcheside, Eckermann.
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Study supervision: Chai-Coetzer, Antic, Eckerman, McEvoy.

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REFERENCES

1. 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):1230-1235.
2. Bearpark H, Elliott L, Grunstein R, et al. Snoring and sleep apnea: a population study in Australian men. *Am J Respir Crit Care Med*. 1995;151(5):1459-1465.
3. Terán-Santos J, Jiménez-Gómez A, Cordero-Guevara J; Cooperative Group Burgos-Santander. The association between sleep apnea and the risk of traffic accidents. *N Engl J Med*. 1999;340(11):847-851.
4. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. *N Engl J Med*. 2000; 342(19):1378-1384.
5. Marin JM, Carrizo SJ, Vicente E, Agusti AGN. Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure. *Lancet*. 2005;365(9464):1046-1053.
6. Engleman HM, Douglas NJ. Sleep. 4: sleepiness, cognitive function, and quality of life in obstructive sleep apnoea/hypopnoea syndrome. *Thorax*. 2004; 59(7):618-622.
7. Dixon T, Waters A. *A Growing Problem: Trends and Patterns in Overweight and Obesity Among Adults in Australia, 1980-2001*. Canberra, Australia: AIHW Bulletin; 2003:8.
8. Mulgrew AT, Fox N, Ayas NT, Ryan CF. Diagnosis and initial management of obstructive sleep apnea without polysomnography. *Ann Intern Med*. 2007; 146(3):157-166.
9. Berry RB, Hill G, Thompson L, McLaurin V. Portable monitoring and autotitration versus polysomnography for the diagnosis and treatment of sleep apnea. *Sleep*. 2008;31(10):1423-1431.
10. Kuna ST, Gurubhagavatula I, Maislin G, et al. Non-inferiority of functional outcome in ambulatory management of obstructive sleep apnea. *Am J Respir Crit Care Med*. 2011;183(9):1238-1244.
11. Antic NA, Buchan C, Esterman A, et al. A randomized controlled trial of nurse-led care for symptomatic moderate-severe obstructive sleep apnea. *Am J Respir Crit Care Med*. 2009;179(6):501-508.
12. Netzer NC, Hoegel JJ, Loube D, et al; Sleep in Primary Care International Study Group. Prevalence of symptoms and risk of sleep apnea in primary care. *Chest*. 2003;124(4):1406-1414.
13. Chai-Coetzer CL, Antic NA, Rowland LS, et al. A simplified model of screening questionnaire and home monitoring for obstructive sleep apnoea in primary care. *Thorax*. 2011;66(3):213-219.
14. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep*. 1991;14(6):540-545.
15. Weaver TE, Laizner AM, Evans LK, et al. An instrument to measure functional status outcomes for disorders of excessive sleepiness. *Sleep*. 1997;20 (10):835-843.
16. Goudge R, Goh N, Barnes M, Howard M, Worsnop C. Validation of a sleep apnoea symptom questionnaire [abstract]. *Am J Respir Crit Care Med*. 2001; 163(5):A933.
17. Brazier JE, Harper R, Jones NM, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *BMJ*. 1992;305(6846): 160-164.
18. Jenkinson C, Davies RJ, Mullins R, Stradling JR. Comparison of therapeutic and subtherapeutic nasal continuous positive airway pressure for obstructive sleep apnoea. *Lancet*. 1999;353(9170):2100-2105.
19. Massie CA, McArdle N, Hart RW, et al. Comparison between automatic and fixed positive airway pressure therapy in the home. *Am J Respir Crit Care Med*. 2003;167(1):20-23.
20. Association AMG. Visit-Specific Satisfaction Questionnaire (VSQ-9). http://www.rand.org/health/surveys_tools/vsq9.html. Accessed March 2, 2012.
21. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care*. 2003;41(5):582-592.
22. Johns MW. Reliability and factor analysis of the Epworth Sleepiness Scale. *Sleep*. 1992;15(4):376-381.
23. Siccoli MM, Pepperell JC, Kohler M, Craig SE, Davies RJ, Stradling JR. Effects of continuous positive airway pressure on quality of life in patients with moderate to severe obstructive sleep apnea. *Sleep*. 2008; 31(11):1551-1558.
24. Hukins CA. Arbitrary-pressure continuous positive airway pressure for obstructive sleep apnea syndrome. *Am J Respir Crit Care Med*. 2005;171 (5):500-505.
25. Andreu AL, Chiner E, Sancho-Chust JN, et al. Effect of an ambulatory diagnostic and treatment programme in patients with sleep apnoea. *Eur Respir J*. 2012;39(2):305-312.
26. Rosen CL, Auckley D, Benca R, et al. A multisite randomized trial of portable sleep studies and positive airway pressure autotitration versus laboratory-based polysomnography for the diagnosis and treatment of obstructive sleep apnea. *Sleep*. 2012;35 (6):757-767.
27. Pietzsch JB, Garner A, Cipriano LE, Linehan JH. An integrated health-economic analysis of diagnostic and therapeutic strategies in the treatment of moderate-to-severe obstructive sleep apnea. *Sleep*. 2011; 34(6):695-709.
28. Ayas NT, Pack A, Marra C. The demise of portable monitoring to diagnose OSA? not so fast! *Sleep*. 2011;34(6):691-692.