

Provider Types and Outcomes in Obstructive Sleep Apnea Case Finding and Treatment

A Systematic Review

Ken M. Kunisaki, MD, MS; Nancy Greer, PhD; Wajahat Khalil, MD; Erin Koffel, PhD; Eva Koeller, BA; Roderick MacDonald, MS; and Timothy J. Wilt, MD, MPH

Background: Obstructive sleep apnea (OSA) diagnosis and care models rely on sleep specialist physicians (SSPs) and can be expensive and inefficient.

Purpose: To assess OSA case-finding accuracy and comparative effectiveness of care by non-sleep specialists (NSSs) and SSPs.

Data Sources: MEDLINE and CINAHL from January 2000 through July 2017.

Study Selection: English-language trials or observational studies comparing case finding or care by SSPs versus providers not specifically trained as SSPs (NSSs) for adults with suspected or diagnosed OSA.

Data Extraction: One investigator extracted data and assessed risk of bias and strength of evidence, with confirmation by a second investigator. Primary outcomes were patient-centered (mortality, access to care, quality of life, patient satisfaction, adherence, symptom scores, and adverse events). Intermediate outcomes included resource use, costs, time to initiation of treatment, and case finding.

Data Synthesis: Four observational studies ($n = 580$; mean age, 52 years; 77% male) reported good agreement between NSSs and SSPs on appropriate diagnostic testing and classification of OSA severity (low-strength evidence). Five randomized trials and

3 observational studies ($n = 1515$; mean age, 52 years; 68% male) found that care provided by NSSs and SSPs resulted in similar quality of life, adherence, and symptom scores (low-strength evidence). Evidence was insufficient for access to care and adverse events.

Limitations: Many outcomes were reported infrequently or not at all. Many NSSs had extensive training or experience in sleep medicine, which limits generalizability of findings to providers with less experience.

Conclusion: Care by NSSs and SSPs resulted in similar outcomes in adults with known or suspected OSA. Studies are needed to determine care model implementation and reproducibility of results in nonacademic settings and among less experienced NSSs.

Primary Funding Source: Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Quality Enhancement Research Initiative. (PROSPERO: CRD42016036810 [full Veterans Affairs Evidence-based Synthesis Program report])

Ann Intern Med. doi:10.7326/M17-2511

For author affiliations, see end of text.

This article was published at Annals.org on 30 January 2018.

Annals.org

Obstructive sleep apnea (OSA) is associated with excessive daytime sleepiness, decreased quality of life, myocardial infarction (1, 2), heart failure (3), stroke (4, 5), and cognitive decline (6, 7). Continuous positive airway pressure (CPAP) improves quality of life and symptoms among persons with OSA and excessive daytime sleepiness (8). Although CPAP has not been shown in randomized trials to reduce myocardial infarctions, stroke, or death (9-12) among patients with OSA, it decreases blood pressure and is associated with reduced risk for motor vehicle accidents (13).

As patients and providers gain awareness of OSA, and as prevalence of obesity (a major risk factor for OSA) increases (14), health care systems need to develop strategies to address the increasing demand for sleep services. The traditional evaluation and care model relies on primary care providers to refer patients with suspected OSA to a sleep specialist physician (SSP). The process often includes consultation, in-laboratory diagnostic polysomnography (PSG), CPAP initiation and titration PSG for persons with OSA, and SSP follow-up of treatment adherence and efficacy. This traditional model may be expensive and inefficient.

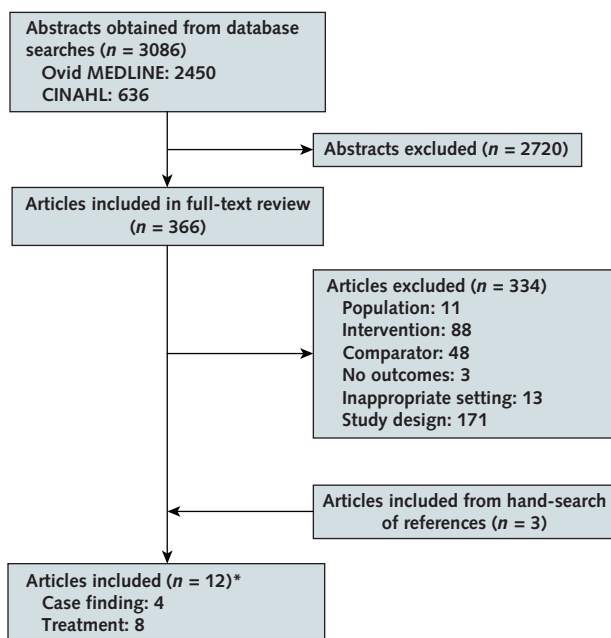
New OSA care models have been proposed and implemented, including home sleep testing for diag-

nostic purposes (15, 16), followed by treatment with an autotitrating CPAP device (17), which has internal algorithms that adjust pressure to keep the airway open during sleep. These models reduce PSG-associated costs and logistical barriers but typically still include SSP consultation and follow-up. Given recent data indicating a decreasing supply of SSPs (18), other models have been proposed that would reduce reliance on SSPs by including providers not specifically trained as SSPs (non-sleep specialists [NSSs]), such as nurses or primary care physicians, to provide the majority of OSA diagnosis and treatment.

Although studies testing some of these new models have been conducted, systematic reviews of studies focusing on who should deliver care are lacking. In this article, we expand on 1 aspect of a larger evidence report conducted for the Department of Veterans Af-

See also:

Web-Only
Supplement
CME/MOC activity

Figure 1. Evidence search and selection.

* An additional 23 studies on autotitrating positive airway pressure vs. continuous positive airway pressure were included in the full evidence report only.

fairs Evidence-based Synthesis Program (protocol registered in PROSPERO [CRD42016036810]) (19) by assessing the comparative effectiveness and harms of new OSA evaluation and treatment models comparing different provider types. Specifically, we evaluated case finding and care by NSSs versus SSPs for patients with suspected or diagnosed OSA.

METHODS

Data Sources and Searches

We searched Ovid MEDLINE and CINAHL for articles published from January 2000 through July 2017. Our search was limited to studies that enrolled adults and were published in English. The search for studies of NSSs versus SSPs included the Medical Subject Headings terms *sleep apnea syndromes*; *sleep apnea, obstructive*; and *health personnel* (Appendix Table 1, available at Annals.org). We obtained additional articles by hand-searching reference lists of relevant studies.

Study Selection

Abstracts and full-text reports were independently reviewed by 2 trained investigators and research associates. Full-text reports of studies identified as potentially eligible after abstract review were obtained for further review. We included randomized or controlled clinical trials and observational studies that reported results in adults with suspected or diagnosed OSA and were conducted in geographic settings likely to have similar populations and sleep medicine resources (United States, Canada, Europe, Australia, and New Zealand). We adopted a broad definition of care mod-

els but required that the study include a comparison of providers with different qualifications (for example, primary care physician vs. SSP).

We did not include studies that compared home sleep testing with sleep laboratory testing if all test results were interpreted by SSPs. We excluded studies evaluating the role of dentists or anesthesiologists and studies in which the goal of the intervention was not OSA care. We also excluded studies if they did not report our outcomes of interest or were dissertations, conference abstracts, case reports, narrative reviews, editorials, or commentaries. Reasons for exclusion of a study at full-text review were noted, and disagreements were resolved by a third reviewer.

Data Abstraction and Quality Assessment

Study characteristics and outcomes were extracted by one investigator and verified by a second. Our outcomes of interest included patient-centered outcomes (mortality, access to care, quality of life, patient satisfaction, adherence, symptom scores, and adverse events) and intermediate or resource-related outcomes (resource use, costs, time to initiation of treatment, and case finding).

Two trained investigators rated the risk of bias of individual studies over all outcomes as low, medium, or high. For randomized controlled trials (RCTs), we based risk-of-bias ratings on the following criteria: allocation sequence generation, allocation concealment, blinding, incomplete outcome data, and selective outcome reporting (20). For observational studies, we rated risk of bias using criteria from the Agency for Healthcare Research and Quality Methods Guide (21). We assessed strength of evidence as high, moderate, low, or insufficient, based on the following domains: study limitations (low, moderate, or high, based on the quality or risk of bias of individual studies), consistency (consistent, inconsistent, or unknown or not applicable), directness (direct or indirect), and precision (precise or imprecise) (22). Strength of evidence was rated by one methodologist and verified by a second. Discrepancies were resolved by discussion.

Data Synthesis and Analysis

We described and qualitatively compared findings of included studies. Analyses were performed in Comprehensive Meta-Analysis, version 3 (Biostat), using random-effects models to calculate mean differences with corresponding 95% CIs.

Role of the Funding Source

The Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Quality Enhancement Research Initiative assigned the topic and reviewed the original protocol but was not involved in data collection, analysis, or manuscript preparation or submission.

RESULTS

Search results are shown in Figure 1. Our search identified 12 studies that were eligible for inclusion.

Case Finding in Adults With Suspected OSA

We identified 4 observational studies on case finding in adults with suspected OSA (23-26). Study characteristics are summarized in **Appendix Table 2** (available at [Annals.org](#)), with additional information provided in **Supplement Table 1** (available at [Annals.org](#)). Two studies received government funding, 1 received both government and respiratory society funding, and 1 did not report a funding source. Each study took a different approach to case finding. Two were rated as having high risk of bias (23, 25), and 2 were rated as having medium risk of bias (24, 26). Although populations, interventions, comparators, and settings differed across studies, outcomes were similar and results suggested good agreement between SSPs and NSSs (**Supplement Tables 2 and 3**, available at [Annals.org](#)).

In a single-site study in the United States, a nurse practitioner experienced in sleep medicine and supervised by an SSP reviewed electronic health records of patients referred for evaluation of OSA (23). The goal was risk stratification and determination of eligibility for an unattended sleep study. If information from the health records was inadequate, a clinic visit with an SSP was scheduled. The health record review (nurse practitioner evaluation) found adequate information for 115 patients, whereas 90 had a clinic visit (SSP evaluation).

A community-based study in the United States included 191 patients with at least 4 hours of interpretable recording time from a portable sleep monitoring device (24). The classification of disease severity that was based on the Apnea-Hypopnea Index value generated by the monitoring device software was compared with the classification that was based on an independent review of the monitoring device output by a board-certified SSP.

In the third study, conducted in Spain, 88 patients with suspected OSA were evaluated by 2 providers: a respiratory physician who was trained in sleep medicine and used results from respiratory polygraphy, and

an SSP who used results from PSG (26). Both evaluations took place within 1 month.

Each of these studies reported on classification of OSA severity (none to severe). Two reported κ coefficients of 0.75 (24) and 0.71 (26), indicating good agreement. The third study only reported that the final diagnoses of severity did not statistically significantly differ between groups (23). We found low-strength evidence that classification of OSA severity was similar (**Table 1**). One of the studies also reported agreement on the Apnea-Hypopnea Index (<10, 10 to 29, or \geq 30 events per hour), with a κ coefficient of 0.65 (26).

The fourth study, also done in Spain, compared the ability of a primary care pulmonologist (described as having “basic knowledge” of sleep medicine) and an SSP to identify the most suitable diagnostic test for individual patients (25). Ninety-six patients were included. A κ coefficient of 0.74 was reported for agreement on the diagnostic test prescribed.

No studies assessed patient satisfaction with care, but 1 study evaluated patient-reported clinical improvement (23). The percentage who perceived clinical improvement at 30-day follow-up was similar ($P = 0.76$) among patients who were evaluated by chart review and those who required a clinic visit. Many of our other outcomes of interest were not reported, including mortality, access to care, quality of life, adherence, symptom scores, adverse events, resource use, costs, and time to initiation of treatment.

Comparative Effectiveness of Management of OSA by NSSs Versus SSPs

We identified 8 studies, including 5 RCTs (27-34). Study characteristics are summarized in **Appendix Table 2**, with additional information provided in **Supplement Table 1**. Five studies reported funding from a combination of government, foundation, and industry sources, including 2 with borrowed or donated equipment. One study reported that no funding was received, and 2 did not report a funding source.

Table 1. Strength of Evidence

Outcome	Strength of Evidence (Rationale)*	Direction
SSP vs. NSS case finding		
OSA severity classification	Low (study limitations)	Similar
SSP care vs. management by primary care physicians, sleep specialist nurses, or other NSSs for suspected OSA		
Access to care	Insufficient	-
Epworth Sleepiness Scale score	Low (study limitations, imprecise results)	Similar improvement from baseline between groups
Quality of life	Low (study limitations, imprecise results)	Similar quality of life at follow-up between groups
Adherence	Low (study limitations, imprecise results)	Similar adherence between groups
Adverse events	Insufficient	-

NSS = non-sleep specialist; OSA = obstructive sleep apnea; SSP = sleep specialist physician.

* Definitions obtained from reference 22. “High” indicates high confidence that the estimate of effect lies close to the true effect; there are few or no deficiencies in the body of evidence, and findings are believed to be stable. “Moderate” indicates moderate confidence that the estimate of effect lies close to the true effect; there are some deficiencies in the body of evidence, and findings are likely to be stable, but there is some doubt. “Low” indicates limited confidence that the estimate of effect lies close to the true effect; there are major or many deficiencies in the body of evidence, and additional evidence is necessary before concluding that findings are stable or that the estimate of effect is close to the true effect. “Insufficient” indicates no evidence, inability to estimate an effect, no confidence in the estimate of effect, or a body of evidence that precludes judgment.

Table 2. Summary of Outcomes: OSA Treatment Provided by SSPs Versus NSSs

Study, Year (Reference)	Sample Size, n	Study Design	Comparative Provider	Follow-up	Quality of Life	Patient Satisfaction (VSQ-9)	Adherence, hours per night
Sánchez-de-la-Torre et al, 2015 (27)	210	RCT	Primary care	6 mo	↔*	↓	↔
Chai-Coetzer et al, 2013 (28)	155	RCT	Primary care	6 mo	↔*†	↓	↔
Lettieri et al, 2011 (31)	210	Cohort	Primary care	4–6 wk	NR	NR	↔
Scharf et al, 2004 (34)	103	Chart review	Primary care	7 mo	NR	↔	NR
Andreu et al, 2012 (29)	65	RCT	Sleep unit nurse	6 mo	↔†	X	↔
Antic et al, 2009 (32)	195	RCT	Sleep specialist nurse	3 mo	↔*†	↓	↔
Palmer et al, 2004 (33)	174	RCT	Sleep specialist nurse	3 mo	↔*	↓	↔
Pamidi et al, 2012 (30)	403	Chart review	NSS¶	30 d	NR	NR	↓
Total**	-	-	-	-	5↔	1↔ 3↓ 1↓ 1X	6↔ 1↓

↔ = nonsignificant difference between NSS and SSP care; ↓ = significantly better with SSP care than NSS care; ↓ = mixed results between NSS and SSP care; † = significantly better with NSS care than SSP usual care, including less resource use; ESS = Epworth Sleepiness Scale; NR = not reported; NSS = non-sleep specialist; OSA = obstructive sleep apnea; RCT = randomized controlled trial; SSP = sleep specialist physician; VSQ-9 = Visit-Specific Satisfaction Instrument; X = between-provider significance not reported.

* Based on Short Form-36 Health Survey scores.

† Based on Functional Outcomes of Sleep Questionnaire scores.

‡ Treatment.

§ Provider contact.

|| Referrals.

¶ Includes primary care, otolaryngology, pulmonology, neurology, endocrinology, cardiology, surgery, and other.

** Numbers indicate the number of studies.

Care by an SSP was compared with primary care management in 4 studies ($n = 678$) (27, 28, 31, 34), sleep specialist nurse care in 3 studies ($n = 434$) (29, 32, 33), and care from other NSSs (60% primary care physicians) in 1 study ($n = 403$) (30). Studies generally included older obese men with excessive daytime sleepiness based on Epworth Sleepiness Scale (ESS) scores and moderate or severe OSA. Among the RCTs, 1 had low risk of bias (32) and 4 had medium risk of bias; the 3 observational studies all had medium risk of bias. Three studies (2 RCTs and 1 cohort study) described interventions in which the SSP had more autonomy than the NSS, who generally delivered protocol-driven, guideline-concordant care (28, 31, 32). Three RCTs compared patients who received similar care delivered by different providers and at different locations (home vs. hospital or clinic) (27, 29, 33). Two retrospective studies provided few details about NSS care (30, 34).

Outcomes are summarized in Table 2, with details provided in Supplement Tables 2 and 3. Quality of life, based on Short Form-36 Health Survey scores (Figure 2 [top]), did not statistically significantly differ between the NSS and SSP groups (low-strength evidence) (Table 1) (28, 32, 33). Mean differences between groups ranged from -0.02 to -0.06 . Similar results were found in studies reporting EuroQol 5-dimension questionnaire scores (27) or Functional Outcomes of Sleep Questionnaire scores (28, 29, 32). Results for patient satisfaction were mixed (27, 28, 32, 33).

Adherence to CPAP (in hours per night) did not statistically significantly differ between the NSS and SSP care groups in any of the 5 RCTs reporting this outcome (Figure 2 [middle]) (27–29, 32, 33). Adherence ranged from 3.6 to 5.9 hours per night in the NSS groups and from 4.2 to 5.6 hours per night in the SSP groups. The mean difference in 3 of the 5 studies was

below the consensus-based threshold of 0.5 hour per night for clinically important improvement adopted by the American Academy of Sleep Medicine (35). We found low-strength evidence that adherence was similar between groups (Table 1).

Epworth Sleepiness Scale scores did not statistically significantly differ for groups receiving care from different providers, with 1 exception (Figure 2 [bottom]) (low-strength evidence [Table 1]) (27–29, 32, 33). Between-group differences in mean change in ESS score from baseline in the 5 RCTs ranged from -1.79 to 1.10 points, all below the consensus-based 2-point threshold adopted by the American Academy of Sleep Medicine for a clinically important difference (35). Furthermore, mean improvements in ESS score from baseline exceeded the 2-point threshold in all studies, regardless of whether care was provided by NSSs (improvement of -4.0 to -9.0 points) or SSPs (improvement of -4.2 to -11.0 points). There were no significant between-group differences in Sleep Apnea Symptom Questionnaire scores (28).

Resource use, cost, and time to initiation of treatment were sporadically reported (Table 2 and Supplement Tables 2 and 3). Measures of resource use varied across studies and included recommendations to use CPAP at follow-up (28, 34), need for help from a specialist (33), and provider contact (29, 32, 33). Results were mixed.

Cost measures also varied. Total average costs were lower when patients were evaluated and followed outside of sleep specialty units (27–29, 32), although only 2 studies (29, 32) reported that the difference was statistically significant. A fifth study reported that the total cost to patients was higher in the clinic visit group, but the cost to the health care system was higher in the nurse home visit group (33).

Table 2—Continued

Adherence (Regular Use)	Symptom Scores (ESS)	Resource Use	Costs	Time to Initiation of Treatment	Adverse Events
NR	↓	NR	X	NR	NR
NR	↔	↔‡	X	NR	NR
↔	↔	NR	NR	NR	NR
↔	NR	↔‡	NR	↓	NR
↔	↔	X§	↑	NR	X
NR	↔	↓ §	↑	NR	NR
NR	↔	↓ §, X	X	NR	NR
↓	NR	NR	NR	NR	NR
3↔	5↔	2↔	2 ↑	1 ↓	1X
1 ↓	1 ↓	1 ↑	3X		
		1 ↓			
		2X			

Only 1 study reported time to treatment initiation and found that significantly more patients were treated with CPAP within 1 month of PSG in the group evaluated and followed by SSPs than in the group evaluated by SSPs but followed by primary care physicians (34). Adverse events, reported in only 1 study, were associated with CPAP treatment (dryness, nasal congestion, and abrasions) and did not differ by provider group (29). Strength of evidence was insufficient for adverse events (Table 1). No study reported mortality or access to care.

DISCUSSION

Our review found good agreement between NSSs and SSPs on appropriate diagnostic testing and classification of OSA severity. We also found that quality of life, symptom scores, and treatment adherence did not statistically significantly differ when care was provided by NSSs versus SSPs. When reported, cost of care was generally lower or did not statistically significantly differ when provided by NSSs compared with SSPs.

Given good agreement for case finding, similar treatment-related outcomes, and possible lower costs among patients diagnosed with OSA, expanded use of NSSs who have received training in sleep medicine could be considered, especially where SSP supply is low and OSA service demand is high. However, the current evidence base is limited; only 1 study was judged to have low risk of bias; and some outcomes, such as time to initiation of treatment and resource use, were infrequently and inconsistently reported.

The primary goal of OSA treatment is to reduce excessive daytime sleepiness. We found that care provided by both NSSs and SSPs resulted in clinically significant mean reductions in daytime sleepiness from

baseline, as defined by a consensus-based 2-point improvement in ESS score. There were no between group differences when comparing NSS versus SSP care with regard to ESS score improvement or CPAP adherence. Although NSS models of OSA care have been proposed (18) and in some cases implemented to improve access to care, no studies reported on access. Information on resource use was sporadically reported but did not show large differences.

Non-sleep specialists were often highly experienced in sleep medicine. In the study by Chai-Coetzer and colleagues (28), the nurse at 1 site had 15 years of experience in a tertiary care sleep medicine service, whereas the NSSs in other studies included respiratory physicians with experience in sleep medicine. Many studies also were conducted in academic settings. Therefore, important questions remain about whether these results can be replicated in nonacademic community settings or among primary care providers who do not have specific experience in sleep medicine. Studies also did not provide clear details on how NSSs were trained or certified to provide OSA case finding and care.

We sought to compare studies in settings with similar sleep medicine resources and therefore included only studies performed in the United States, Canada, Europe, Australia, or New Zealand. We also excluded studies of dentists and anesthesiologists because they typically provide focused, limited sleep services and may not be NSSs. We found no studies of care models that used sleep respiratory therapists or behavioral sleep medicine providers. We also did not find prior systematic reviews pertaining to provider type.

Most enrolled patients were obese middle-aged men with moderate to severe symptomatic OSA; there-

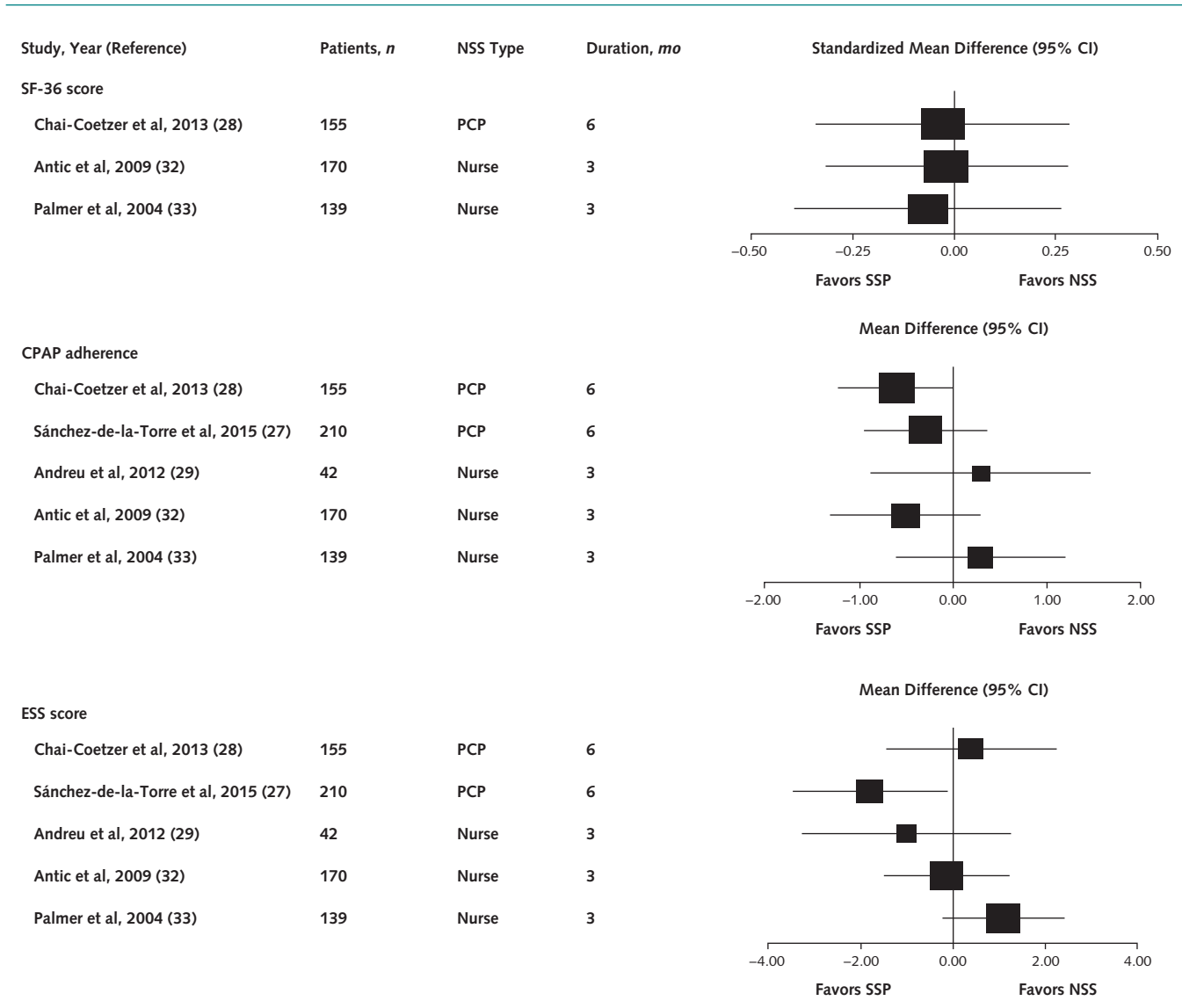
fore, whether our findings can be generalized to women, nonobese persons, or those with milder and less symptomatic OSA remains unknown. Furthermore, the findings may not be generalizable to patients with low pretest probability of OSA; patients with minimal daytime sleepiness; or complex patients, such as those with concomitant disorders like central sleep apnea, hypoventilation disorders, and other comorbid sleep conditions.

We included studies in which NSS and SSP provider types were compared. Although our review found no difference between NSS and SSP care, 2 studies showed that patients with OSA receiving care from board-certified SSPs or at accredited facilities were more likely to be adherent to CPAP and satisfied with their care than those receiving care from non-board-

certified SSPs or at nonaccredited facilities (36, 37). These data suggest that training and other quality measures may be an important factor in patient outcomes. Such factors were not described in most studies we reviewed and should be better described in future studies.

Our report focused on methods that might improve the supply side of OSA evaluation and treatment through improvements in efficiency via use of NSSs. However, health care systems struggling to match supply to demand might also consider prioritizing the demand side. The evidence to date indicates that the main benefit of OSA detection and treatment is improvement in patient-reported daytime sleepiness and associated quality of life rather than reduction of fatal and nonfatal cardiovascular outcomes (8-12). Health

Figure 2. Outcomes for NSSs vs. SSPs from randomized trials.



CPAP = continuous positive airway pressure; ESS = Epworth Sleepiness Scale; NSS = non-sleep specialist; PCP = primary care physician; SF-36 = Short Form-36 Health Survey; SSP = sleep specialist physician. **Top.** Standardized mean differences in change from baseline in SF-36 Mental Component Summary score. **Middle.** Mean differences (in hours per night) in CPAP adherence. **Bottom.** Mean differences in change from baseline in ESS score.

care providers and decision makers could achieve the highest-value care, including optimal resource use, by targeting case-finding approaches and subsequent evaluation and treatment to persons with unexplained daytime sleepiness, as recommended by the U.S. Preventive Services Task Force and the American College of Physicians (38–40).

Pragmatic trials are needed to determine whether the results we observed can be achieved in routine practice, outside of controlled research settings and among primary care providers without extensive experience in sleep medicine. We are aware of 1 randomized trial in progress (funded by the Patient-Centered Outcomes Research Institute) that, although it includes a major academic sleep center, is testing the effectiveness of a collaborative model involving primary care plus a sleep center versus a traditional sleep center-based model (41). Implementation studies such as these would help determine whether and how NSS models can be operationalized to achieve optimal patient-centered outcomes. Such studies should ideally describe methods to train and provide quality assurance for NSSs.

In conclusion, low-strength evidence suggests that case finding and OSA management outcomes are similar whether provided by primary care physicians, sleep specialist nurses, or SSPs. Evidence was insufficient to assess whether provider type affects access to care or adverse events. Future studies are needed to determine whether these results can be replicated in non-academic settings and among primary care providers without extensive sleep medicine experience and how such care models should be implemented.

From Minneapolis Veterans Affairs Health Care System and University of Minnesota, Minneapolis, Minnesota; Minneapolis Veterans Affairs Health Care System Evidence-based Synthesis Program Site and Center for Chronic Disease Outcomes Research, Minneapolis, Minnesota; and Minneapolis Veterans Affairs Health Care System Evidence-based Synthesis Program Site and Center for Chronic Disease Outcomes Research and University of Minnesota, Minneapolis, Minnesota.

Disclaimer: The views expressed in this article are those of the authors and do not reflect the views of the U.S. government, the Department of Veterans Affairs, or any of the authors' affiliated academic institutions.

Financial Support: By the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Quality Enhancement Research Initiative. The Office of Research and Development also provided protected research time in support of this study.

Disclosures: Authors have disclosed no conflicts of interest. Forms can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M17-2511.

Reproducible Research Statement: *Study protocol:* The protocol for the full evidence report is registered in PROSPERO (CRD42016036810). *Statistical code:* Not applicable. *Data set:* See the supplement tables.

Requests for Single Reprints: Timothy J. Wilt, MD, MPH, Professor of Medicine, University of Minnesota School of Medicine, Minneapolis VA Center for Chronic Disease Outcomes Research, 1 Veterans Drive (111-0), Minneapolis, MN 55417; e-mail, tim.wilt@va.gov.

Current author addresses and author contributions are available at Annals.org.

References

1. Marin JM, Carrizo SJ, Vicente E, Agusti AG. Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study. *Lancet*. 2005;365:1046-53. [PMID: 15781100]
2. Peker Y, Hedner J, Norum J, Kraiczi H, Carlson J. Increased incidence of cardiovascular disease in middle-aged men with obstructive sleep apnea: a 7-year follow-up. *Am J Respir Crit Care Med*. 2002;166:159-65. [PMID: 12119227]
3. Gottlieb DJ, Yenokyan G, Newman AB, O'Connor GT, Punjabi NM, Quan SF, et al. Prospective study of obstructive sleep apnea and incident coronary heart disease and heart failure: the Sleep Heart Health Study. *Circulation*. 2010;122:352-60. [PMID: 20625114] doi:10.1161/CIRCULATIONAHA.109.901801
4. Redline S, Yenokyan G, Gottlieb DJ, Shahar E, O'Connor GT, Resnick HE, et al. Obstructive sleep apnea-hypopnea and incident stroke: the Sleep Heart Health Study. *Am J Respir Crit Care Med*. 2010;182:269-77. [PMID: 20339144] doi:10.1164/rccm.200911-1746OC
5. Yaggi HK, Concato J, Kernan WN, Lichtman JH, Brass LM, Mohsenin V. Obstructive sleep apnea as a risk factor for stroke and death. *N Engl J Med*. 2005;353:2034-41. [PMID: 16282178]
6. Blackwell T, Yaffe K, Laffan A, Ancoli-Israel S, Redline S, Ensrud KE, et al; Osteoporotic Fractures in Men (MrOS) Study Group. Associations of objectively and subjectively measured sleep quality with subsequent cognitive decline in older community-dwelling men: the MrOS Sleep Study. *Sleep*. 2014;37:655-63. [PMID: 24899757] doi:10.5665/sleep.3562
7. Yaffe K, Laffan AM, Harrison SL, Redline S, Spira AP, Ensrud KE, et al. Sleep-disordered breathing, hypoxia, and risk of mild cognitive impairment and dementia in older women. *JAMA*. 2011;306:613-9. [PMID: 21828324] doi:10.1001/jama.2011.1115
8. Giles TL, Lasserson TJ, Smith BH, White J, Wright J, Cates CJ. Continuous positive airways pressure for obstructive sleep apnoea in adults. *Cochrane Database Syst Rev*. 2006;CD001106. [PMID: 16855960]
9. McEvoy RD, Antic NA, Heeley E, Luo Y, Ou Q, Zhang X, et al; SAVE Investigators and Coordinators. CPAP for prevention of cardiovascular events in obstructive sleep apnea. *N Engl J Med*. 2016;375:919-31. [PMID: 27571048] doi:10.1056/NEJMoa1606599
10. Barbé F, Durán-Cantolla J, Sánchez-de-la-Torre M, Martínez-Alonso M, Carmona C, Barceló A, et al; Spanish Sleep And Breathing Network. Effect of continuous positive airway pressure on the incidence of hypertension and cardiovascular events in nonsleepy patients with obstructive sleep apnea: a randomized controlled trial. *JAMA*. 2012;307:2161-8. [PMID: 22618923] doi:10.1001/jama.2012.4366
11. Parra O, Sánchez-Armengol A, Bonnin M, Arboix A, Campos-Rodríguez F, Pérez-Ronchel J, et al. Early treatment of obstructive apnoea and stroke outcome: a randomised controlled trial. *Eur Respir J*. 2011;37:1128-36. [PMID: 20847081] doi:10.1183/09031936.00034410
12. Peker Y, Glantz H, Eulenburg C, Wegscheider K, Herlitz J, Thunström E. Effect of positive airway pressure on cardiovascular outcomes in coronary artery disease patients with nonsleepy obstructive sleep apnea. The RICCADSA randomized controlled trial. *Am J Re-*

- spir Crit Care Med. 2016;194:613-20. [PMID: 26914592] doi:10.1164/rccm.201601-0088OC
13. Montesi SB, Edwards BA, Malhotra A, Bakker JP. The effect of continuous positive airway pressure treatment on blood pressure: a systematic review and meta-analysis of randomized controlled trials. *J Clin Sleep Med.* 2012;8:587-96. [PMID: 23066375] doi:10.5664/jcsm.2170
14. NCD Risk Factor Collaboration (NCD-RisC). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. *Lancet.* 2016;387:1377-96. [PMID: 27115820] doi:10.1016/S0140-6736(16)30054-X
15. Collop NA, Anderson WM, Boehlecke B, Claman D, Goldberg R, Gottlieb DJ, et al; Portable Monitoring Task Force of the American Academy of Sleep Medicine. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients. Portable Monitoring Task Force of the American Academy of Sleep Medicine. *J Clin Sleep Med.* 2007;3:737-47. [PMID: 18198809]
16. El Shayeb M, Topfer LA, Stafinski T, Pawluk L, Menon D. Diagnostic accuracy of level 3 portable sleep tests versus level 1 polysomnography for sleep-disordered breathing: a systematic review and meta-analysis. *CMAJ.* 2014;186:E25-51. [PMID: 24218531] doi:10.1503/cmaj.130952
17. Ip S, D'Ambrosio C, Patel K, Obadan N, Kitsios GD, Chung M, et al. Auto-titrating versus fixed continuous positive airway pressure for the treatment of obstructive sleep apnea: a systematic review with meta-analyses. *Syst Rev.* 2012;1:20. [PMID: 22587875] doi:10.1186/2046-4053-1-20
18. Phillips B, Gozal D, Malhotra A. What is the future of sleep medicine in the United States? [Editorial]. *Am J Respir Crit Care Med.* 2015;192:915-7. [PMID: 26308722] doi:10.1164/rccm.201508-1544ED
19. Kunisaki KM, Khalil W, Koffel E, Pfannes L, Koeller E, MacDonald R, et al. The Comparative Effectiveness, Harms, and Cost of Care Models for the Evaluation and Treatment of Obstructive Sleep Apnea (OSA): A Systematic Review. VA Evidence-based Synthesis Program Reports no. 09-009. Washington, DC: U.S. Department of Veterans Affairs; 2016.
20. Higgins JPT, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions.* Version 5.1.0. The Cochrane Collaboration; 2011.
21. Viswanathan M, Ansarai MT, Berkman ND, Chang S, Hartling L, McPheeters M, et al. Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions. Rockville: Agency for Healthcare Research and Quality; 2008.
22. Owens DK, Lohr KN, Atkins D, Treadwell JR, Reston JT, Bass EB, et al. AHRQ series paper 5: grading the strength of a body of evidence when comparing medical interventions—Agency for Healthcare Research and Quality and the Effective Health-Care Program. *J Clin Epidemiol.* 2010;63:513-23. [PMID: 19595577] doi:10.1016/j.jclinepi.2009.03.009
23. Alsharif AM, Potts M, Laws R, Freire AX, Sultan-Ali I. Unattended sleep studies in a VA population: initial evaluation by chart review versus clinic visit by a midlevel provider. *South Med J.* 2016;109:677-81. [PMID: 27706510]
24. Aurora RN, Putcha N, Swartz R, Punjabi NM. Agreement between results of home sleep testing for obstructive sleep apnea with and without a sleep specialist. *Am J Med.* 2016;129:725-30. [PMID: 26968467] doi:10.1016/j.amjmed.2016.02.015
25. Chamorro N, Sellarés J, Millán G, Cano E, Soler N, Embid C, et al. An integrated model involving sleep units and primary care for the diagnosis of sleep apnoea [Letter]. *Eur Respir J.* 2013;42:1151-4. [PMID: 24081767] doi:10.1183/09031936.00192812
26. Hernández L, Torrella M, Roger N, Lluñell A, Ballester E, Quinto L, et al. Management of sleep apnea: concordance between non-reference and reference centers. *Chest.* 2007;132:1853-7. [PMID: 17925431]
27. Sánchez-de-la-Torre M, Nadal N, Cortijo A, Masa JF, Duran-Cantolla J, Valls J, et al; Respiratory Medicine Research Group. Role of primary care in the follow-up of patients with obstructive sleep apnoea undergoing CPAP treatment: a randomised controlled trial. *Thorax.* 2015;70:346-52. [PMID: 25766689] doi:10.1136/thoraxjnl-2014-206287
28. Chai-Coetzer CL, Antic NA, Rowland LS, Reed RL, Esterman A, Catchside PG, et al. Primary care vs specialist sleep center management of obstructive sleep apnea and daytime sleepiness and quality of life: a randomized trial. *JAMA.* 2013;309:997-1004. [PMID: 23483174] doi:10.1001/jama.2013.1823
29. Andreu AL, Chiner E, Sancho-Chust JN, Pastor E, Llombart M, Gomez-Merino E, et al. Effect of an ambulatory diagnostic and treatment programme in patients with sleep apnoea. *Eur Respir J.* 2012;39:305-12. [PMID: 21719490] doi:10.1183/09031936.00013311
30. Pamidi S, Knutson KL, Ghods F, Mokhlesi B. The impact of sleep consultation prior to a diagnostic polysomnogram on continuous positive airway pressure adherence. *Chest.* 2012;141:51-7. [PMID: 21700685] doi:10.1378/chest.11-0709
31. Lettieri CF, Lettieri CJ, Carter K. Does home sleep testing impair continuous positive airway pressure adherence in patients with obstructive sleep apnea? *Chest.* 2011;139:849-54. [PMID: 21292757] doi:10.1378/chest.10-1060
32. Antic NA, Buchan C, Esterman A, Hensley M, Naughton MT, Rowland S, et al. A randomized controlled trial of nurse-led care for symptomatic moderate-severe obstructive sleep apnea. *Am J Respir Crit Care Med.* 2009;179:501-8. [PMID: 19136368] doi:10.1164/rccm.200810-1558OC
33. Palmer S, Selvaraj S, Dunn C, Osman LM, Cairns J, Franklin D, et al. Annual review of patients with sleep apnea/hypopnea syndrome—a pragmatic randomised trial of nurse home visit versus consultant clinic review. *Sleep Med.* 2004;5:61-5. [PMID: 14725828]
34. Scharf SM, DeMore J, Landau T, Smale P. Comparison of primary-care practitioners and sleep specialists in the treatment of obstructive sleep apnea. *Sleep Breath.* 2004;8:111-24. [PMID: 15389385]
35. Kapur VK, Auckley DH, Chowdhuri S, Kuhlmann DC, Mehra R, Ramar K, et al. Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine clinical practice guideline. *J Clin Sleep Med.* 2017;13:479-504. [PMID: 28162150] doi:10.5664/jcsm.6506
36. Parthasarathy S, Haynes PL, Budhiraja R, Habib MP, Quan SF. A national survey of the effect of sleep medicine specialists and American Academy of Sleep Medicine accreditation on management of obstructive sleep apnea. *J Clin Sleep Med.* 2006;2:133-42. [PMID: 17557485]
37. Parthasarathy S, Subramanian S, Quan SF. A multicenter prospective comparative effectiveness study of the effect of physician certification and center accreditation on patient-centered outcomes in obstructive sleep apnea. *J Clin Sleep Med.* 2014;10:243-9. [PMID: 24634620] doi:10.5664/jcsm.3518
38. U.S. Preventive Services Task Force. Obstructive Sleep Apnea in Adults: Screening. January 2017. Accessed at www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/obstructive-sleep-apnea-in-adults-screening on 6 February 2017.
39. Qaseem A, Dallas P, Owens DK, Starkey M, Holty JE, Shekelle P; Clinical Guidelines Committee of the American College of Physicians. Diagnosis of obstructive sleep apnea in adults: a clinical practice guideline from the American College of Physicians. *Ann Intern Med.* 2014;161:210-20. [PMID: 25089864] doi:10.7326/M12-3187
40. Qaseem A, Holty JE, Owens DK, Dallas P, Starkey M, Shekelle P; Clinical Guidelines Committee of the American College of Physicians. Management of obstructive sleep apnea in adults: a clinical practice guideline from the American College of Physicians. *Ann Intern Med.* 2013;159:471-83. [PMID: 24061345]
41. Kushida CA, Nichols DA, Holmes TH, Miller R, Griffin K, Cardell CY, et al. SMART DOCS: a new patient-centered outcomes and coordinated-care management approach for the future practice of sleep medicine. *Sleep.* 2015;38:315-26. [PMID: 25409112] doi:10.5665/sleep.4422

Current Author Addresses: Drs. Kunisaki, Greer, Khalil, Koffel, and Wilt; Ms. Koeller; and Mr. MacDonald: Minneapolis VA Health Care System, One Veterans Drive, Minneapolis, MN 55417.

Author Contributions: Conception and design: K.M. Kunisaki, N. Greer, W. Khalil, E. Koffel, E. Koeller, T.J. Wilt. Analysis and interpretation of the data: K.M. Kunisaki, N. Greer, W. Khalil, E. Koffel, E. Koeller, R. MacDonald, T.J. Wilt. Drafting of the article: K.M. Kunisaki, N. Greer, E. Koffel, E. Koeller, R. MacDonald, T.J. Wilt. Critical revision of the article for important intellectual content: K.M. Kunisaki, N. Greer, W. Khalil, E. Koffel, T.J. Wilt. Final approval of the article: K.M. Kunisaki, N. Greer, W. Khalil, E. Koffel, E. Koeller, R. MacDonald, T.J. Wilt. Statistical expertise: R. MacDonald, T.J. Wilt. Obtaining of funding: T.J. Wilt. Administrative, technical, or logistic support: N. Greer, T.J. Wilt. Collection and assembly of data: K.M. Kunisaki, N. Greer, E. Koffel, E. Koeller, R. MacDonald, T.J. Wilt.

Appendix Table 1. Search Strategies

Ovid MEDLINE

1.	Sleep Apnea Syndromes/di,th
2.	Sleep Apnea, Obstructive/di,th
3.	(protocol: or algorithm:).mp.
4.	Patient care team/ or nurse's practice patterns/ or health personnel/ or allied health personnel/
5.	Sleep apnea syndromes/nu or sleep apnea, obstructive/nu
6.	(nurse led or nurse-led).ti,ab.
7.	(nurse: or nursing or technician:).mp.
8.	Primary health care/ or physicians/ or (nurse* or technician or special* or primary care or physician).ti,ab.
9.	"referral and consultation"/ or (electronic adj consult).mp. or consult*.mp. or telemedicine/ or remote consultation/
10.	Mass screening/
11.	Continuous positive airway pressure/mt, nu
12.	Polysomnography/nu
13.	Chart review.mp. or risk assessment/
14.	1 or 2
15.	3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13
16.	14 and 15
17.	Limit 16 to (English language and yr="2000-Current")
18.	Limit 17 to "all child (0 to 18 years)"
19.	Limit 17 to "all adult (19 plus years)"
20.	18 not 19
21.	17 not 20

CINAHL

1.	(MH "Sleep Apnea Syndromes/DI/TH")
2.	(MH "Sleep Apnea, Obstructive/DI/TH")
3.	AB (protocol* or algorithm*)
4.	(MH "Multidisciplinary Care Team") OR "MH "Team Nursing") OR (MH "Total Patient Care Nursing")
5.	(MH "Nursing Practice") OR (MH "Scope of Nursing Practice")
6.	(MH "Health Personnel") OR (MH "Allied Health Personnel")
7.	(MH "Sleep Apnea Syndromes/NU") OR (MH "Sleep Apnea, Obstructive/NU")
8.	"nurse led"
9.	"nurse-led"
10.	AB (nurse* or nursing or technician*)
11.	(MH "Primary Health Care")
12.	(MH "Physicians")
13.	(MH "Referral and Consultation") OR (MH "Remote Consultation")
14.	(MH "Telemedicine")
15.	AB (electronic adj consult) OR AB consult*
16.	(MH "Health Screening")
17.	(MH "Continuous Positive Airway Pressure/MT/NU")
18.	(MH "Polysomnography/NU")
19.	1 or 2
20.	S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18
21.	19 AND 20 (Limits: Published dates 2000 to present, English Language)

Appendix Table 2. Summary of Study Characteristics

Characteristic	Value (Range)	Studies Reporting, <i>n</i>
Case finding		
Total participants enrolled, <i>n</i>	580 (88-205)	4
Total participants treated by sleep specialist nurse, <i>n</i>	115	1
Total participants treated by NSS, <i>n</i>	184 (88-96)	2
Weighted mean age of participants, <i>y</i>	52 (48-58)	4
Weighted mean percentage of men	77 (63-91)	4
Weighted mean baseline BMI, <i>kg/m²</i>	31 (28-35)	4
Mean baseline Epworth Sleepiness Scale score	12	1
Weighted mean percentage of participants with hypertension*	40 (25-55)	3
Total participants by location, <i>n</i>		
United States	396 (191-205)	2
Europe	184 (88-96)	2
Care management		
Total participants enrolled, <i>n</i>	1515 (65-403)	8
Randomized controlled trials	799 (65-210)	5
Other trials	716 (103-403)	3
Total participants treated by primary care physician, <i>n</i>	678 (103-210)	4
Total participants treated by sleep specialist nurse, <i>n</i>	434 (65-195)	3
Total participants treated by other NSS, <i>n</i>	403	1
Weighted mean age of participants, <i>y</i>	52 (48-56)	8
Weighted mean percentage of men	68 (47-86)	8
Weighted mean baseline BMI, <i>kg/m²</i>	34 (30-36)	7
Weighted mean baseline Epworth Sleepiness Scale score	11 (9-16)	7
Weighted mean baseline Apnea-Hypopnea Index score, <i>events/h</i>	37 (21-51)	4
Weighted mean percentage of participants with hypertension*	56 (49-59)	3
Total participants by location, <i>n</i>		
United States	716 (103-403)	3
Europe	449 (65-210)	3
Australia/New Zealand	350 (155-195)	2
Total participants required to have daytime sleepiness, <i>n</i>	415 (65-195)	3

BMI = body mass index; NSS = non-sleep specialist.

* As defined by study.