

# Redesigning Care for OSA



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Constrained by a limited supply of specialized personnel, health systems face a challenge in caring for the large number of patients with OSA. The complexity of this challenge is heightened by the varied clinical presentations of OSA and the diversity of treatment approaches. Innovations such as simplified home-based care models and the incorporation of nonspecialist providers have shown promise in the management of uncomplicated patients, producing comparable outcomes to the resource-intensive traditional approach. However, it is unclear if these innovations can meet the needs of all patients with OSA, including those with mild disease, atypical presentations, and certain comorbid medical and mental health conditions. This review discusses the diversity of needs in OSA care, the evidence base behind recent care innovations, and the potential limitations of each innovation in meeting the diversity of care needs. We propose how these innovations can fit within the stepped care and hub and spoke models in a way that addresses the full spectrum of OSA, and we discuss future research directions to assess the deployment of these innovations. CHEST 2020; 157(4):966-976

**KEY WORDS:** home sleep apnea testing; hub and spoke; nonspecialist-led care; OSA; stepped care

OSA presents a global challenge to health-care systems, affecting > 1 billion individuals worldwide.<sup>1-3</sup> OSA treatment among many of these individuals will improve quality of life and important health outcomes,<sup>4,5</sup> but our capacity to provide appropriate services is constrained. For instance, the United States has only 6,000 board-certified sleep specialists to serve an adult population of 250 million.<sup>6</sup> This mismatch is one contributor to significant underdiagnosis and long wait times for care.<sup>7,8</sup> Adding complexity to care

delivery, OSA varies considerably in its presentation, implications, and treatment. A fundamental redesign in care is necessary to address these challenges. This review elaborates on the complexity of care delivery and research that informs opportunities to meet this challenge among adult patients in high-income settings.

## Spectrum of OSA and Its Treatment

OSA presents heterogeneously, with associated symptoms and comorbid

**ABBREVIATIONS:** ASV = adaptive servoventilation; ECHO = Extension for Community Healthcare Outcomes; MAD = mandibular advancement device; PAP = positive airway pressure; PSG = polysomnography; PTSD = posttraumatic stress disorder

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conditions impacting management. OSA severity is classified into categories of mild, moderate, and severe by the apnea hypopnea index,<sup>9</sup> but these thresholds do not reliably predict symptom presentation.<sup>10,11</sup> Excessive daytime sleepiness is the symptom classically connected with OSA,<sup>12</sup> but is only present in 40% to 58% of cases,<sup>10,11,13</sup> whereas 33% to 54% primarily have insomnia symptoms and approximately 25% are asymptomatic.<sup>13-16</sup> Symptom presentation has important implications because symptom and comorbidity-based phenotypic clusters are connected to treatment outcomes and response to therapy. Similar to other cluster analyses,<sup>14-16</sup> Gagnadoux et al<sup>17</sup> identified distinct OSA phenotypes based on symptoms, sex, and comorbidities. Among these clusters, positive airway pressure (PAP) therapy success (eg,  $\geq 4$  h/night of PAP use and improved symptoms) differed substantially. Patients with insomnia, more medical comorbidities, and minimal sleepiness had up to 75% lower likelihood of treatment success.<sup>17</sup> Analyses of an Icelandic cohort found similar results regarding treatment effects.<sup>18</sup>

Certain comorbid conditions merit particular consideration and are the topics of ongoing research. For instance, 30% of patients with heart failure have OSA,<sup>19</sup> and while PAP therapy does not appear to prevent incident heart failure,<sup>20,21</sup> treatment is linked to improved ejection fraction and quality of life.<sup>22</sup> Heart failure also merits consideration given the mortality risk of treating central sleep apnea with a specific PAP mode, adaptive servoventilation (ASV).<sup>23</sup> Treating OSA may also hasten recovery and prevent recurrence among those with recent stroke,<sup>24-28</sup> and observational studies suggest OSA treatment could prevent exacerbations and mortality among those with COPD.<sup>29-31</sup> OSA management also impacts the care of mental health disorders. OSA is present in up to 44% of patients with depression and 43% of those with posttraumatic stress disorder (PTSD), and OSA treatment is associated with symptom improvement in each condition.<sup>32-40</sup>

A comprehensive redesign must also incorporate diverse treatment options. Although CPAP remains the initial treatment of choice,<sup>41</sup> other therapies may be more appropriate for some. This includes PAP options beyond CPAP (eg, bilevel PAP, ASV). These complex modes deliver a higher inspiratory than expiratory pressure, and are often used for OSA with concomitant hypoventilation (eg, bilevel) or central sleep apnea (eg, ASV).<sup>41-43</sup> After PAP, the most extensively studied therapies are mandibular advancement devices (MADs). MADs are fitted by dentists, relieve obstruction in mild-

to-moderate OSA,<sup>44,45</sup> and are useful for those with conditions impairing PAP adherence (eg, PTSD, claustrophobia).<sup>46</sup> MAD therapy requires coordination between dentist and sleep specialist<sup>44</sup> because sleep studies are necessary to evaluate efficacy and titrate mandibular protrusion.<sup>47</sup> Surgical options reduce airway resistance by eliminating tissues, extending the mandible and maxilla, bypassing the upper airway via tracheostomy, or stimulating the hypoglossal nerve with an implanted stimulator.<sup>48-50</sup> Similar to MADs, surgery is less efficacious than PAP and therefore more appropriate for mild-to-moderate OSA or those intolerant of PAP.<sup>48,50</sup> Close collaboration between surgeon and sleep specialist is also necessary to plan procedures and assess response.<sup>48</sup> Conservative measures including lifestyle modification targeting reversible OSA contributors rarely cure OSA in isolation, but should be considered for all patients. These measures include weight loss, exercise, alcohol avoidance, and nonsupine sleeping position.<sup>51</sup> Weight loss in particular has the added benefit of improving overall cardiovascular and mortality risk.<sup>52</sup> Although it is currently unclear how to best integrate these myriad options, many foresee a future personalized approach that acknowledges disease severity (eg, apnea hypopnea index), biological activity (eg, biomarkers), patient impact (eg, sleepiness), and pathophysiological traits (eg, arousal threshold, loop gain).<sup>53</sup>

## Recent Innovations to Expand Care for OSA

Recent studies feature two major innovations: home-based pathways and nonsleep specialist care. These innovations are also explored elsewhere in systematic reviews.<sup>54,55</sup>

### Home-Based Pathways

Polysomnography (PSG), a resource-intensive test requiring overnight monitoring by a technologist,<sup>9</sup> was traditionally required to diagnose OSA and tailor therapy. Home-based pathways use home sleep apnea testing devices to diagnose OSA and autotitrating PAP devices that automatically adjust pressures.<sup>56,57</sup> Home tests typically detect respiratory events using nasal pressure, oximetry, and respiratory effort (level 3 studies) or oximetry plus one other channel (level 4). An alternative home diagnostic technology measures respiratory disturbance with peripheral arterial tonometry.<sup>9</sup> Multiple trials have compared home-based pathways with standard laboratory-based care. These trials found home-based care led to cost savings of 25% to 57%<sup>58,59</sup> and comparable treatment decisions,

CPAP adherence, and patient-reported improvements in sleepiness and quality of life.<sup>58-62</sup>

Home-based pathways transform OSA care access.<sup>63,64</sup> Unlike sleep laboratories that require substantial investments in personnel and physical structures, home-based pathways allow health systems to more feasibly scale resources to meet patient needs.<sup>65</sup> Home-based pathways also simplify management, creating opportunities for nonsleep specialists to provide care.

Although home-based pathways have considerable advantages, there are limitations.<sup>9</sup> Home tests are less sensitive than PSG. Home tests typically do not directly measure sleep by electroencephalography and overestimate sleep time, reducing estimates of OSA severity—particularly among individuals with insomnia.<sup>9</sup> Also, respiratory events causing arousals but not desaturations are missed by many home tests.<sup>66</sup> Because of reduced sensitivity, studies validating home-based pathways only included those with high pretest probability of OSA,<sup>9</sup> limiting our understanding of the utility of home-based pathways in patients with lower pretest probability. This limitation was at least partly addressed by a trial of in-laboratory limited channel PSGs which included subjects with low pretest probability of OSA. Chai-Coetzer et al<sup>56</sup> found in-laboratory level 3 studies led to comparable provider decision-making and outcomes relative to full PSG, whereas level 4 studies led to greater provider uncertainty and poorer patient outcomes. It is worth noting that generalizability of these results to everyday clinical practice is unclear given additional barriers to accuracy (eg, signal loss, user error) with unattended tests.<sup>59</sup> Home tests and autotitrating CPAP devices also have difficulty distinguishing central from obstructive events.<sup>67-69</sup> Therefore, trials of home-based pathways excluded patients at high risk for central sleep apnea (eg, heart failure, cerebrovascular disease).

### *Nonsleep Specialist-Directed Care*

One key limitation in providing OSA care is the lack of sleep specialists.<sup>6</sup> Common conditions such as COPD and depression face similar disparities between prevalence of disease and specialist availability,<sup>70,71</sup> and primary care manages these conditions in most patients.<sup>72,73</sup> Research illustrates the possible role of primary care providers and other nonspecialists in expanding access. The first observational study of primary care OSA management was published in 2004 and demonstrated similar CPAP adherence relative to sleep specialist care.<sup>74</sup> Four randomized controlled trials

followed. Three enrolled patients prediagnosis,<sup>75-77</sup> and one enrolled patients with established OSA.<sup>78</sup> In each study, primary care providers performed OSA counseling and made therapy decisions.<sup>78</sup> Sánchez-Quiroga et al<sup>76</sup> eliminated all sleep specialist input by incorporating automated sleep study scoring and interpretation. Overall, patient-reported sleepiness and CPAP adherence were comparable at 6 months.<sup>75-78</sup>

Three trials specifically compared nurse-led management with sleep specialist physician care.<sup>79-81</sup> Two studies randomized patients to receive sleep apnea care from a nurse or a physician sleep specialist.<sup>79,80</sup> One study randomized patients with known OSA to nurse home visits or annual clinic-based specialist appointments.<sup>81</sup> In each study, sleep symptoms and PAP adherence were comparable between groups with lower costs in the nurse-led pathway.<sup>79-81</sup>

Finally, one recent trial compared respiratory therapist-led management with sleep specialist care.<sup>82</sup> Respiratory therapist management led to more timely care and a greater reduction in sleep symptoms. However, the primary end point for noninferiority in PAP adherence was not met, with results suggesting patients treated by respiratory therapists may have lower PAP adherence.

### *Limitations and Knowledge Gaps in Nonspecialist-Led Care*

Although promising, we should exercise caution in extending nonspecialist care to all patients, particularly those with certain comorbidities, those requiring non-CPAP therapies, and those without classic symptoms.

Nearly all of the aforementioned trials targeted patients with excessive daytime sleepiness,<sup>75,76,78-80</sup> and many specifically excluded comorbid sleep disorders.<sup>76-79</sup> This constrains our understanding of nonspecialist care to patients with somnolent phenotypes,<sup>17,18</sup> who are more likely to have treatment success with PAP alone.<sup>17,83</sup> The utility of PAP for patients without sleepiness is unclear, and PAP use among many patients may represent an expensive treatment of low value. Patients with atypical presentations may benefit from non-PAP therapies, and many asymptomatic patients may not require any treatment.<sup>17,18,84-88</sup> In the setting of untreated OSA with insomnia, specialists would be of particular utility in delivering cognitive behavioral therapy and carefully monitoring hypnotic medication use.<sup>89-93</sup> The treatment of OSA with residual hypersomnolence (approximately 12% of patients with OSA)<sup>94</sup> may also require specialists. Expert consultation may be helpful in evaluating the etiology of hypersomnolence<sup>95-98</sup> and risks of wake

promoting agents (eg, modafinil) and sympathomimetics (eg, methylphenidate).<sup>99-105</sup> Finally, it is unclear if nurses can appropriately diagnose OSA among patients with greater diagnostic uncertainty because the two trials of prediagnosis nurse-led care were limited to patients with high pretest probability.<sup>79,80</sup>

Most trials excluded patients with important medical comorbidities including heart failure, COPD, and stroke,<sup>75,77-80</sup> and with the exception of Pendharkar et al,<sup>82</sup> the randomized trials without explicit exclusions had relatively small numbers of these patients or did not report their prevalence.<sup>76,81</sup> Primary care providers are adept at managing and coordinating care for these comorbidities, but the treatment of sleep disorders in this context requires specialized expertise that is not widely mastered. For instance, patients with stroke and heart failure are thought to be more likely to have central sleep apnea<sup>106,107</sup>; however, recent research has called the connection with stroke into question.<sup>108</sup> Caring for central sleep apnea is complicated by considerable controversy in optimal management strategy,<sup>42,109-111</sup> and cardiovascular mortality risk incurred by treating central sleep apnea with ASV in certain patients with heart failure.<sup>23</sup> Care must also be taken among patients with COPD because of the risk of comorbid respiratory failure. Although not specifically studied among patients with concomitant OSA, very high inspiratory pressure targets can improve mortality among patients with COPD and respiratory failure,<sup>112-114</sup> something not observed with less intensive bilevel settings or CPAP.<sup>115,116</sup> Beyond medical comorbidities, individuals with comorbid mental health disorders such as PTSD have particular difficulties with adherence and may be especially vulnerable to less intensive management.<sup>30,46,117,118</sup> However, five of the trials excluded those with significant psychiatric disease.<sup>75,77-80</sup> In light of these disease-specific considerations and the consequences of inadequately managed disease, future research is needed to understand the role of nonsleep specialists in caring for patients with these comorbidities.

A final limitation is the ability of nonspecialists to use the full spectrum of OSA treatments. Approximately 25% of patients are not adherent to CPAP in recent observational studies,<sup>43</sup> indicating the need to incorporate alternative treatments. However, non-CPAP therapies were largely excluded from the aforementioned studies. In the only study including non-CPAP therapies, nonspecialists who were relatively new to OSA care chose non-CPAP therapies half as

often as specialists (31% vs 16%).<sup>75</sup> A greater reliance on CPAP may reflect a lack of comfort and experience with alternatives (Table 1).<sup>46</sup>

## Treating the Full Spectrum of Patients

Home-based pathways and nonsleep specialist-directed care are promising innovations, but by themselves these solutions do not facilitate care for the diverse population of patients with OSA. We need to incorporate lessons from other health-care services to design an alternative comprehensive model. The two following complementary models have particular resonance with OSA care: the stepped care model and hub and spoke model.

A fundamental task will be to properly align patients with appropriate services, shifting tasks from specialists to other providers where appropriate. Stepped care models pursue this goal by (1) assessing patients' disease severity and needs, (2) matching appropriate care strategies, and (3) reassessing patients to ensure continued alignment. In doing so, stepped care models achieve improved outcomes for conditions such as depression in a cost-efficient manner.<sup>119,120</sup> Beyond care alignment, geographic deployment of services needs to be optimized. OSA differs from conditions such as depression by the degree to which it depends on specialized equipment for both diagnosis and management. Although home tests provide portability, in-laboratory PSG remains a geographically fixed scarce resource required by some patients. Furthermore, dispensation of PAP treatment requires specialized durable medical equipment providers whose capacity is limited in many regions.<sup>121</sup>

The hub and spoke model incorporates geographic organization that addresses these issues. This model organizes health-care systems to concentrate complex interventions and expertise in centralized hubs and distributes routine care in peripheral spoke sites.<sup>122</sup> Similar to the stepped care model, the hub and spoke model shifts appropriate tasks from specialists in hubs to nonspecialist spoke providers. In doing so, hub and spoke models improve quality of care and patient outcomes for complex conditions (eg, acute stroke),<sup>123</sup> and achieve cost savings by using specialized services more efficiently.<sup>124</sup> For OSA care, sleep specialists' clinics and laboratories are the natural hubs given their access to sophisticated technology (eg, PSG) and highly trained staff (eg, sleep specialists, respiratory therapists, polysomnographic technologists).<sup>125,126</sup> Sleep centers also have relationships with dentists and surgeons to provide expertise for

**TABLE 1 ] Strengths and Limitations of Traditional and Novel Practices in OSA Care**

Laboratory-Based Testing	Home-Based Testing
<b>Advantages:</b> <ul style="list-style-type: none"> <li>• Accurate assessment of the following:               <ul style="list-style-type: none"> <li>- Severity of OSA</li> <li>- Comorbid sleep disorders</li> </ul> </li> <li>• Low failure rates</li> </ul>	<b>Advantages:</b> <ul style="list-style-type: none"> <li>• Reduced wait times</li> <li>• Favorable costs</li> <li>• Easier scalability</li> <li>• Straightforward results which facilitate nonspecialist involvement</li> </ul>
<b>Limitations:</b> <ul style="list-style-type: none"> <li>• Resource intensive and costly</li> <li>• Longer wait times</li> <li>• Limited availability of sleep laboratories</li> <li>• Patient discomfort</li> </ul>	<b>Limitations:</b> <ul style="list-style-type: none"> <li>• Poor accuracy among:               <ul style="list-style-type: none"> <li>- Less symptomatic patients</li> <li>- Patients with atypical presentations</li> <li>- Limited assessment of non-OSA sleep disordered breathing</li> </ul> </li> </ul>
Specialist-Led Care	Nonspecialist-Led Care
<b>Advantages:</b> <ul style="list-style-type: none"> <li>• No need to alter existing care pathways and systems</li> </ul>	<b>Advantages:</b> <ul style="list-style-type: none"> <li>• Greater availability of providers</li> <li>• Cost reduction relative to specialists</li> </ul>
<b>Limitations:</b> <ul style="list-style-type: none"> <li>• Low availability of providers</li> <li>• Costs of specialist directed care</li> <li>• Geographic proximity to patients</li> </ul>	<b>Limitations:</b> <ul style="list-style-type: none"> <li>• Knowledge gaps: care of comorbid sleep disorders, non-PAP options</li> </ul>

PAP = positive airway pressure.

non-PAP therapies. Primary care providers and nonspecialists appear best suited to be spoke providers, with their care focused on the home-based pathway. Patients meeting the inclusion criteria for the bulk of these trials of home-based and nonspecialist delivered care would be appropriate for spoke-based treatment, whereas patients excluded from these trials would be more suitable for hub-based care. Consistent with the stepped care model, we must also consider longitudinal reassessment. For instance, many patients with straightforward moderate-to-severe OSA initially treated by spoke providers will require referral to hub providers to consider non-PAP treatments (eg, oral appliances). Conversely, many patients with concomitant hypoventilation requiring a hub-based bilevel titration may be appropriate for subsequent spoke-based follow-up for common PAP-related complaints (eg, mask discomfort, leak). Given the prevalence of obesity in OSA and its critical health importance,<sup>52</sup> obesity-related treatments including comprehensive lifestyle interventions and pharmacotherapy should be offered at both hub and spoke.<sup>127</sup> In addition to delineating the roles and appropriate patients for services at hubs vs spokes, lessons learned from the creation of other hub and spoke systems suggest the importance of ensuring (1) access to services at both the hub and spoke level, and (2) adequate communication between hub and spoke providers.<sup>122</sup>

Two methods to improve access merit discussion: embedded specialty care and telehealth. Challenging

prevailing separate silos for primary and specialty care, some systems embed specialists within primary care clinics to reduce patients' travel burden and promote interprovider communication.<sup>128</sup> In mental health, such embedded models improve patient access and outcomes.<sup>128,129</sup> In our context, an embedded OSA model would colocate hub and spoke based-services. One could imagine embedded OSA specialists being primarily useful in large primary care clinics and specialty clinics enriched in patients with complicated OSA care (eg, heart failure clinics). By contrast, embedded care is unlikely to be feasible for smaller primary care practices because of insufficient demand. Telehealth can also play an instrumental role. Telehealth reduces access disparities for rural and homebound patients, but may not increase the number of patients cared for by a given specialist.<sup>130,131</sup> Video-based care by sleep providers is accepted by patients and leads to comparable short-term OSA treatment outcomes with in-person management.<sup>132</sup> Small studies also indicate promise for delivering cognitive behavioral therapy for insomnia through a telehealth platform.<sup>133</sup> Although hub-based services are intuitive targets for the incorporation of video-based care, spoke services could also be provided remotely.

A framework to maintain communication between hub and spoke providers is provided by the Extension for Community Healthcare Outcomes (ECHO) program introduced in the United States in the early 2000s. This program was originally designed to assist rural

nonspecialists provide high-quality care for individuals with hepatitis C, and has since been extended worldwide for many conditions.<sup>134</sup> ECHO relies on videoconference-based educational programs between spoke and hub providers to enhance provider self-efficacy through focused didactics and case-based collaborative mentoring. Parsons et al<sup>135</sup> illustrated the feasibility of ECHO for sleep care telementorship. In ten 1-h sessions, sleep specialists provided mentorship to 39 nonspecialists who endorsed improved confidence in the care of sleep disorders.<sup>135</sup> In the redesign of OSA care, optimal deployment of telementorship needs to be considered (Table 2).

### Future Directions

As previously outlined, we suggest health systems incorporate nonspecialist care in the context of both the stepped care and hub and spoke models. The stepped care model informs how to match patients to appropriate provider roles both initially and longitudinally (Tables 1, 2), whereas the hub and spoke model informs geographic organization. We suggest health systems use these frameworks to incorporate nonspecialists such as primary care providers and nurses as spoke providers with roles outlined in Tables 1 and 2. Additionally, health systems should also consider other options to streamline care and improve effectiveness. For instance, a number of trials and guidelines support use of remote PAP telemonitoring, which enables systems to target PAP adherence interventions across a population. Observational work also supports the incorporation of nurse practitioners into specialist roles.<sup>136</sup>

Consistent with a learning health system model, we will need to conduct observational research to monitor and

improve our redesign. Such observational studies will evaluate the feasibility of deploying nonspecialists in sleep care beyond the well-resourced academic centers, effectiveness on patient outcomes, costs, and barriers to implementation. Institutions already using similar models (eg, Kaiser Permanente, Veterans Health Administration) are excellent candidates for such investigation. These evaluations can leverage the wealth of observational data available from administrative and billing data, electronic medical records, and PAP usage datasets. As with any major health-care implementation, qualitative and quantitative assessments of patient and provider experience will be crucial.<sup>137</sup> Of particular interest will be the interaction of patients and providers with new technological innovations. For instance, we need to assess how novel telehealth tools, such as video visits, impact provider productivity. We also need to assess determinants of patient trust and satisfaction as we implement novel innovations into the real-world setting. For instance, the randomized trials of home-based and nonspecialist management noted comparable satisfaction between groups,<sup>55,60</sup> but recent evidence from typical practice suggests satisfaction may be lower with simplified home-based care.<sup>138</sup>

Although rigorous observational work will be needed, we anticipate several barriers will exist based on past experience. Although we focus in this review on the limited number of sleep specialists or hub providers, barriers also exist for nonspecialist spoke providers. Based on our experience, recruiting and training these spoke providers will be difficult. Primary care providers are already overtaxed,<sup>139</sup> and many may not be able to expand their roles. Pulmonologists are other potential spoke providers given their exposure

**TABLE 2 ]** Proposed Criteria for Patients Most Appropriate for Hub vs Spoke-Based Care

Hub Care	Spoke Care
<p>Initial care:</p> <ul style="list-style-type: none"> <li>• Predominant insomnia symptoms</li> <li>• Active psychiatric disease or cognitive impairment</li> <li>• Patients at high risk for central sleep apnea or hypoventilation syndromes</li> <li>• Low pretest probability of OSA and minimal daytime sleepiness who request testing/treatment</li> </ul> <p>Follow-up care:</p> <ul style="list-style-type: none"> <li>• Significant hypoxemia on initial sleep testing</li> <li>• Inability to tolerate initial PAP therapy</li> <li>• Patients interested in non-PAP therapies (mandibular advancement device, sleep surgery)</li> </ul>	<p>Initial care:</p> <ul style="list-style-type: none"> <li>• Absence of clinical suspicion of sleep related-hypoventilation and central sleep apnea</li> <li>• High diagnostic likelihood of moderate-to-severe OSA</li> <li>• Absence of comorbid sleep disorders (eg, insomnia, restless leg syndrome, parasomnias)</li> </ul> <p>Follow-up care:</p> <ul style="list-style-type: none"> <li>• Able to tolerate PAP therapy</li> <li>• Patients who have initiated non-PAP therapies with adequate initial response</li> <li>• Patients with high-risk comorbidities who have completed initial hub-based treatment</li> </ul>

See Table 1 legend for expansion of abbreviation.

to OSA during training,<sup>140</sup> but pulmonologists comprise an already scarce resource.<sup>71</sup> Furthermore, although care provided in spokes may be streamlined and straightforward, logistical hurdles may complicate care. Electronic medical record integration between hub and spoke will be crucial. Health systems and payers will also need to work together to overcome logistical barriers related to reimbursement. For instance, although prior authorizations may have a role in reining in expensive hub-based care,<sup>65</sup> it makes little sense to impose such barriers to the relatively inexpensive services provided in spokes (eg, home sleep apnea testing).<sup>121</sup>

In addition to observational studies, future randomized trials should also be pursued to assess care pathways and practices that are not yet ready for implementation. Trials will be helpful to assess the comparative effectiveness of nonspecialist-led care for those with complex high-risk comorbidities such as congestive heart failure and nonspecialist-led care for emerging personalized care pathways.<sup>53</sup> Trials should also be incorporated as we further explore novel technologies such as the use of artificial intelligence, a potential tool for clinical decision support and sleep diagnostic test interpretation.<sup>141</sup> An expanded role for the patient in self-management, potentially using consumer health tools, should also be rigorously studied in the context of care redesign.<sup>142</sup>

Effective management of OSA requires that we provide appropriate care for the full spectrum of patients. Recent trials furnish important information regarding the utility of home-based pathways and the role of nonspecialists in uncomplicated patients. As outlined, the hub and spoke and stepped care models serve as useful guides to deploy these innovations, but future research will be needed to assess their impact on patient outcomes.

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