

SCIENTIFIC INVESTIGATIONS

## Positive airway pressure therapy supplied by an integrated sleep practice associated with greater adherence among pre-Medicare-aged patients with sleep-disordered breathing

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**Study Objectives:** We investigated whether patient adherence to positive airway pressure (PAP) therapy was significantly different between groups whose PAP machines were dispensed by a traditional durable medical equipment (DME) supplier (DME group) versus those provided directly by an integrated sleep practice (ISP group).

**Methods:** This was a retrospective cohort study that analyzed 3884 patients (ages 18-64) who were set up with a new PAP machine for sleep-disordered breathing. The channel through which PAP therapy was dispensed (DME vs ISP) was chosen as part of the natural course of treatment, making patient choice and third-party payor likely important selection factors. We analyzed whether the groups had significant differences in adherence rates and nightly usage duration after 30 days, 90 days, and 1 year of therapy.

**Results:** The ISP group had a significantly higher rate of PAP adherence at 30 days (71% vs 66%;  $P = .004$ ), 90 days (66% vs 56%;  $P < .00001$ ), and 1 year (52% vs 33%;  $P < .00001$ ) following initiation of PAP therapy, relative to the DME group. There was a significantly higher duration of PAP use among the ISP group at 30 days (357 vs 345 minutes;  $P = .002$ ), 90 days (348 vs 319 minutes;  $P < .00001$ ), and 1 year (312 vs 164 minutes;  $P < .00001$ ).

**Conclusions:** This study suggests improved short- and long-term PAP adherence rates among patients who received PAP therapy through an ISP. As current health care trends drive sleep medicine practices to adopt chronic care management models, further studies are needed to better understand the tradeoffs of receiving PAP through traditional DME providers.

**Keywords:** positive airway pressure, CPAP, obstructive sleep apnea, sleep apnea, sleep-disordered breathing, CPAP usage, adherence

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### BRIEF SUMMARY

**Current Knowledge/Study Rationale:** There are numerous studies related to patient adherence to positive airway pressure therapy. However, the connection between patient adherence and the channel in which positive airway pressure therapy is dispensed has not been studied to date.

**Study Impact:** This study suggests that an integrated approach to dispensing positive airway pressure therapy may more effectively promote short- and long-term adherence than the common practice of dispensing positive airway pressure therapy through a traditional durable medical equipment supplier.

### INTRODUCTION

Obstructive sleep apnea is a medical condition characterized by brief and repeated episodes of upper airway collapse during sleep. Untreated obstructive sleep apnea has been shown to have numerous adverse effects, including impaired daytime functioning, increased mortality, neurocognitive impairment, increased risk of traffic accidents, and higher chronic disease burden.<sup>1-3</sup> Despite the fact that positive airway pressure (PAP) therapy remains one of the most important treatment options for obstructive sleep apnea, long-term adherence remains a major barrier to successful treatment.<sup>1,4,5</sup>

Suboptimal adherence is not a problem unique to the use of PAP therapy. In developed countries worldwide, nonadherence rates for chronic disease care are estimated to be between 25%

and 50%.<sup>6-8</sup> Under the World Health Organization framework,<sup>9</sup> nonadherence to treatments for chronic disease is considered in a context broader than a patient's acceptance of recommended therapy. Rather, adherence is viewed as a multifaceted interplay between numerous factors, such as the patient, the health care delivery system, the medical condition, the nature of therapy, and the socioeconomic environment. The health care delivery system, in particular, can affect the accessibility of services, data availability, procedures around health information management, and training of clinicians. Regardless, programs that support adherence are characterized by robust lines of communication between the patient and his/her health care team,<sup>10</sup> ideally in support of behavioral change.

The sleep medicine literature is rich with studies exploring demographic, clinical, and technological factors predictive of

adherence to PAP therapy. Such studies have most consistently suggested that PAP adherence has been associated with consistent PAP usage early in the course of treatment,<sup>11–16</sup> apnea-hypopnea index,<sup>16–18</sup> pretreatment sleepiness,<sup>11,16,17,19</sup> and perceived improvement in sleepiness after treatment.<sup>16,18,20</sup> The correlation with other seemingly important factors, such as patient age, sex, race, and presence of side effects, has been less consistent.<sup>5</sup> In addition to these factors, recent fascinating work has studied the impact that psychological constructs from the behavioral change literature<sup>21–26</sup> seem to play on continuous PAP adherence.<sup>21,27,28</sup> One of the factors influencing health behaviors that has been underexplored in the PAP adherence literature are the structural health system impediments<sup>26</sup> that limit the effectiveness of individuals' attempts at self-management. Under the traditional model of PAP fulfillment, a clinical provider writes a prescription for PAP therapy, while a durable medical equipment (DME) company supplies the machine. Because of the numerous entities involved in PAP care delivery, this division of labor has the potential to contribute to unintended effects such as fragmented communication and heterogeneous troubleshooting procedures. This may lead not only to an additional barrier but also to lost opportunity to educate about the associated health risks and facilitate adherence. Furthermore, the cognitive link between PAP device usage and health outcomes may become less apparent to the patient when much of the PAP instruction is provided outside of a medical practice. Often, the prescribing provider can be left out of the troubleshooting process altogether before a patient has made the decision to discontinue therapy. This may be problematic, given some evidence that an existing relationship with a sleep specialist prior to diagnosis of sleep-disordered breathing (SDB) is associated with higher PAP adherence.<sup>29</sup> Similarly, adherent patients tend to be more satisfied with the level of communication and education they have received from the providers and staff providing their sleep care.<sup>30,31</sup> Practices may also be in a better position to address the common comorbid conditions that can affect PAP adherence.<sup>32,33</sup> As such, sleep specialty clinics may be well equipped to deliver timely interventions to promote PAP adherence, provided they effectively leverage their interdisciplinary clinical team to address some of the common barriers to PAP adherence.

The purpose of this study was to explore differences in PAP adherence between patients receiving PAP therapy from a traditional DME provider and those patients receiving PAP therapy through an integrated sleep practice (ISP). We hypothesized superior PAP adherence among patients who receive PAP therapy directly from an ISP, relative to those receiving PAP therapy from a DME supplier.

## METHODS

This study was approved by the Institutional Review Board at Middle Tennessee State University.

### Study population

This retrospective cohort study followed patients who received their sleep care from Sleep Centers of Middle Tennessee, a

community-based sleep practice serving approximately 20,000 patients per year. Providers and staff at Sleep Centers of Middle Tennessee are provided specific training to support patients using principles of evidence-based behavioral sleep medicine.<sup>27,34,35</sup> The training was designed to be applied by the provider at initial evaluation and follow-up visits, by the polysomnographic technologist at sleep studies, and by DME staff during the initial PAP set-up visit.

We collected PAP adherence and demographic data from patients who initiated PAP therapy between January 1998 and June 2018. As such, those patients diagnosed with SDB but who pursued an alternative treatment modality or were lost to follow-up prior to receiving PAP therapy were not included. For a best attempt at including only the continuous PAP-naïve population, patients with more than 1 continuous PAP provider over this 20-year interval were excluded from the final analysis. In addition, patients who started PAP therapy multiple times with the same DME provider had only data from the first trial analyzed. To exclude age confounders introduced by anti-self-referral (ie, Stark) regulations, patients 65 years of age or older at the time of PAP therapy initiation were excluded from the final analysis. Patients younger than 18 years of age or missing demographic characteristics were also excluded. Finally, to ensure that data were reliably transmitted via cellular modem, we included only patients from a subset of 4 DME companies that started treatment with PAP after 1 January 2012. After this date, these DME providers agreed to keep wireless modems turned on indefinitely.

### Procedures

All patients included in the study, regardless of the experimental group, had initial sleep clinic visits with the same providers from the same sleep practice. Both groups of patients received the same patient educational content during this visit. The procedures surrounding technical administration, interpretation, and results communication of diagnostic studies were also the same for each group of patients.

Upon receiving a diagnosis of SDB, patients were allowed to choose their DME provider, based on insurance compatibility and personal preference. Patients received their PAP supplies from either the ISP (ISP group) or 1 of 4 participating DME suppliers (DME group) who agreed to leave the wireless modem activated indefinitely. For patients initiating PAP therapy in the ISP group, DME staff were trained to elicit expectations and anticipated problems with continuous PAP therapy, then to counsel and educate patients with the principles of motivational enhancement in mind.<sup>34</sup> Participating DME providers were also provided with a written copy of the practice's PAP initiation protocols.

The protocol for scheduling follow-up visits was the same for patients from each group, regardless of the DME provider. In general, the interval for each follow-up visit was guided by the participants' success with PAP adherence. Patients were asked to return for short-term follow-up (ie, 3 months or less) until they achieved an average usage of at least 6 hours per night. Once a patient achieved an average of at least 6 hours of nightly adherence, they were scheduled for yearly follow-up.

## Statistical analysis

Adherence rates for each of the groups were calculated at 30 days, 90 days, and 1 year after the initiation of PAP therapy. An individual patient was classified as being adherent during each of these intervals if he/she had at least 4 hours of PAP usage for at least 70% over the respective interval. For example, a patient would be classified as adherent at 90 days if he/she used PAP for at least 4 hours on at least 63 of the first 90 days of use. Adherence rates between the experimental groups were compared with chi-square test at each of these intervals.

Average nightly durations of PAP use at 30 days, 90 days, and 1 year were also compared between groups. Each patient's PAP usage was averaged over the respective time interval. Given nonparametric distribution of the mean nightly usage for each group, the duration of PAP usage was compared between groups with a 1-sided Mann-Whitney *U* test.

## RESULTS

### Study participants

Between January 1998 and June 2018, there were 15,853 patients in the original dataset who initiated PAP therapy for SDB. Of these, 967 patients were excluded because they had a PAP machine dispensed from both the ISP and a traditional DME company over this time period, leaving 7,448 participants in the ISP group and 6,471 participants in the DME group. After excluding patients who were started on PAP therapy outside of the target date range, 2,257 participants remained in the ISP group while 3,009 participants remained in the DME group. Patients without demographic data (235 excluded from ISP, 240 excluded from DME) and outside of the age interval of 18–64 years (189 excluded from ISP, 714 excluded from DME) were excluded. Of the 2,055 patients remaining in the DME group, 2,001 patients chose 1 of the 4 participating DME companies that agreed to keep the modems on indefinitely. Available characteristics from each of these final groups are shown in [Table 1](#).

### Rate of PAP adherence

As stated above, patients were classified as adherent if PAP therapy was used for at least 4 hours on at least 70% of days over 30-day, 90-day, and 1-year intervals. [Table 2](#) shows the adherence rates for each of these groups at these intervals. Of the 2,001 patients included in the DME group, 1,327 patients (66%) were adherent at 30 days, 1,116 patients (56%) were adherent at 90 days, and 665 patients (33%) were adherent at 1 year. Of the 1,833 patients included in the ISP group, 1,296 patients (71%) were adherent at 30 days, 1,212 patients were adherent at 90 days (66%), and 961 patients (52%) were adherent at 1 year. Chi-square analysis showed that the ISP group had a significantly higher rate of adherence at 30 days ( $P = .004$ ), 90 days ( $P < .00001$ ), and 1 year ( $P < .00001$ ). Because of the significantly higher rate of Whites and lower rate of Blacks in the ISP group, the differences between experimental groups were also analyzed between these subgroups. The results of this subgroup analysis are displayed in [Table 2](#).

**Table 1**—Baseline group characteristics.

Characteristic	ISP Group	DME Group	<i>P</i>
Male, %	64.7	60.1	.003*
Mean age, years	46.7	47.4	.04*
White, %	84.5	80.5	.001*
Black, %	8.1	10.8	.004*
Other race/refused to report, %	7.4	8.6	.16
Maintained on CPAP, %	92.5	92.8	.78
Maintained on BPAP, %	6.2	5.6	.45

\*Statistically significant at  $P < .05$ . BPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; DME = durable medical equipment; ISP = integrated sleep practice.

### Nightly duration of PAP usage

To determine whether there was a longer duration of PAP usage among patients in the ISP group, each participant's nightly usage was averaged over the respective 30 days, 90 days, and 1 year following PAP initiation. Of the 3,884 patients included in the final analysis, all patients had evidence of at least some PAP usage. The median durations of average nightly usage among the DME group at 30 days, 90 days, and 1 year were 345 minutes, 319 minutes, and 164 minutes, respectively. Median durations of average nightly usage among the ISP group at 30 days, 90 days, and 1 year were 357 minutes, 348 minutes, and 312 minutes, respectively. To test our hypothesis that the ISP group had superior usage duration among its participants, 1-sided Mann-Whitney *U* test showed significant differences between groups at 30 days ( $P = .002$ ), 90 days ( $P < .00001$ ), and 1 year ( $P < .00001$ ). Comparisons between race subgroups are displayed in [Table 3](#).

## DISCUSSION

The purpose of this study was to explore differences in PAP adherence between patients receiving PAP therapy from a traditional DME provider and those receiving PAP therapy through an ISP. To evaluate aggregated adherence differences, we first compared the proportion of adherent patients between each group. Our findings suggest superior PAP adherence rates in the ISP group, both in the short term (30 days, 90 days) and the long term (1 year). This difference remained significant when comparing the White subgroups. For the Black subgroup, this difference in adherence rate between ISP and DME groups was significant only at 1 year. In addition to superior rates of patient adherence, the average nightly usage was also found to be superior between experimental groups at all time points. This difference remained significant among all time points in the White subgroup and at 1 year in the Black subgroup. The long-term adherence rate of 52% in the ISP group was comparable to rates published previously,<sup>11,30</sup> while average nightly use of 5.2 hours in the ISP group was slightly better than averages previously published<sup>11,36</sup>

Some may have noted differences in adherence rate between Black and White subgroups. These differences were found to be

**Table 2**—Number of patients adherent (adherence rate) at key time intervals: ISP vs DME groups.

	ISP Group	DME Group	P
White, n	1549	1611	
30 days	1113 (73)	1107 (69)	.006*
90 days	1059 (68)	940 (58)	<.00001*
1 year	841 (54)	577 (36)	<.00001*
Black, n	148	217	
30 days	80 (54)	123 (57)	.62
90 days	70 (47)	99 (46)	.75
1 year	53 (35)	50 (23)	.008*
Total, n	1833	2001	
30 days	1296 (71)	1327 (66)	.004*
90 days	1212 (66)	1116 (56)	<.00001*
1 year	961 (52)	665 (33)	<.00001*

Values are n (%) unless otherwise indicated. For each group, patients were classified as being adherent if they achieved at least 4 hours of PAP use on at least 70% of nights over the respective time interval. P values were calculated with chi-square test. \*Statistically significant at P < .05. DME = durable medical equipment; ISP = integrated sleep practice; PAP = positive airway pressure.

**Table 3**—Median average nightly use of individuals still using PAP at key time intervals: ISP vs DME groups.

	ISP Group	DME Group	P
White			
30 days	366 (± 123)	353 (± 125)	.004*
90 days	358 (± 132)	327 (± 133)	<.00001*
1 year	322 (± 157)	184 (± 163)	<.00001*
Black			
30 days	311 (± 125)	298 (± 117)	.62
90 days	284 (± 136)	279 (± 128)	.39
1 year	233 (± 150)	122 (± 143)	.001*
Total			
30 days	357 (± 125)	345 (± 126)	.002*
90 days	348 (± 134)	319 (± 134)	<.00001*
1 year	312 (± 157)	164 (± 160)	<.00001*

Each patient’s nightly duration of use was averaged over the respective intervals. The usage durations reported in the table describe the median (± SD) of each group’s average nightly use, in minutes. P values were calculated with 1-sided Mann-Whitney U test. \*Statistically significant at P < .05. DME = durable medical equipment; ISP = integrated sleep practice; PAP = positive airway pressure.

significant at all time points (1 month, 3 months, and 1 year) within both the ISP group and the DME group. Although this issue was not addressed in the initial set of hypotheses, we felt this was an important finding that should be added to the current body of literature.<sup>30,36–39</sup> There are likely multiple contributing factors through which race contributes to lower adherence rates, including shorter sleep duration<sup>40</sup> and differences in cultural attitudes about sleep.<sup>41</sup> It is also likely a proxy for other important latent variables such as socioeconomic status, which has also been shown to influence PAP adherence.<sup>30,38,42</sup> While monitoring these practice metrics in the future, we hope future work can uncover effective strategies for addressing these important mediating factors.

Many clinicians working in sleep medicine have experienced the suboptimal communication patterns and patient confusion

related to fragmented care when dispensing PAP therapy through the heterogeneous landscape of traditional DME providers. As a result, some clinicians may find improved rates of adherence with integrated PAP care to be intuitive. Although interaction between PAP initiation and DME providers has not been well studied, we hypothesize that such integration has the potential to improve communication between the patient and his/her interdisciplinary team, a factor known to be important in promoting adherence to many interventions.<sup>10</sup> Second, an integrated care model fundamentally improves the degree of standardization over the people and processes required to initiate PAP therapy. As such, implementation and monitoring of new processes based on best-available evidence become more feasible. For example, over the period studied, the practice’s PAP initiation protocol was provided to participating DME

companies, but we were only able to confirm that the protocol was followed by those patients who chose the ISP as a PAP provider. Although some may see this as a limitation in the study design, we believe that such standardization could be an explanatory factor for the demonstrated differences in adherence rate. It is worth noting that, although the PAP initiation protocol was a practical application of evidence-based principles designed to improve attitudes and beliefs about treatment, it did not go through the rigor of formal validation.

Restrictions surrounding age of participant enrollment was another major study constraint. Because our study involved patient referral to the practice's internal DME company, federal laws prohibiting physician self-referral<sup>43</sup> (commonly known as the Stark law) precluded inclusion of Medicare patients into the ISP group. To avoid introducing age as a confounding factor between groups, patients eligible for Medicare on the basis of age were excluded from the study altogether, potentially limiting the generalizability to a typical sleep medicine clinic population.

This study has several other important limitations to keep in mind. First, as is often the case with retrospective cohort studies, there were statistically significant demographic imbalances between groups that may have biased the results. Also, given the disparate adherence and clinical datasets, we were unable to explore other important confounding factors, such as socioeconomic status, SDB severity, specific SDB diagnosis, and baseline sleepiness. Admittedly, our methods to include only PAP-naïve patients were imperfect because patients who previously attempted PAP therapy outside of our region's DME providers (including the ISP) could not be reliably excluded from our final analysis. However, we do not believe that there were systematic differences that would have introduced higher rates of previously PAP-intolerant individuals into either experimental group. Although only a subset of the above confounding factors have consistently proven to influence adherence,<sup>5,16,17,19,30,36–38</sup> future work should continue to focus on controlling for these important factors. Finally, along the same lines, a truly patient-centric study would have been able to explore differences in other important outcomes, such as improvements in sleepiness or neurocognitive symptoms. However, in light of previous evidence showing a linear dose–response between the duration of PAP usage and these outcomes,<sup>30,36,44,45</sup> the metrics available to us may provide a useful proxy to guide future patient-centered outcome studies.

Despite these limitations, the study explored a pervasive issue, affecting both academic and community-based sleep practices. The interactions between the traditional DME providers and PAP adherence have been underexplored in the peer-reviewed literature. The large difference in long-term (1-year) adherence rates between groups, in particular, warrants further exploration into the role that the heterogeneous landscape of traditional DME providers plays in long-term PAP adherence. As current health care trends drive sleep medicine practices to adopt remote monitoring and chronic care management models, further studies are needed to better understand the tradeoffs of receiving PAP therapy through traditional DME providers.

## ABBREVIATIONS

DME, durable medical equipment  
 ISP, integrated sleep practice  
 PAP, positive airway pressure  
 SDB, sleep-disordered breathing

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## SUBMISSION & CORRESPONDENCE INFORMATION

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## DISCLOSURE STATEMENT

This work was performed at the Sleep Centers of Middle Tennessee, Vanderbilt University Medical Center, Middle Tennessee State University. The authors report no conflicts of interest.