

Retrospective descriptive study of CPAP adherence associated with use of the ResMed myAir application

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Abstract

Digital health technologies are gaining increased recognition as having the potential to improve adherence to continuous positive airway pressure (CPAP) therapy. This retrospective analysis found that 83.9% of brand new CPAP users who received standard care and who used the ResMed myAir self-management application, which incorporates empirically-tested behavioural science strategies, achieved Medicare adherence in 90 days and 75.4% achieved adherence in 30 days. The median number of days to achieve adherence was 23 (95% confidence interval, 23-23). The adherence rates achieved in this study suggest that myAir has a positive effect on CPAP adherence.

Introduction

Nocturnal continuous positive airway pressure (CPAP) is considered the gold standard treatment for sleep apnea. However, adherence to CPAP is essential for the health benefits of therapy to be realised. The US Medicare policy for continued coverage of a CPAP device requires objective evidence of CPAP use for ≥ 4 hours per night on at least 70% of nights during a consecutive 30-day period anytime during the first 3 months of initial usage [1]. Yet there is no globally-accepted definition of good CPAP adherence in terms of the level of usage required to achieve and maintain therapeutic effectiveness.

There appears to be a direct relationship between the effectiveness of CPAP therapy and the hours of use across a wide range of measures, from daytime sleepiness and neurocognitive function to reductions in BP and cardiovascular events [2-14]. However, a "one size fits all" approach to defining optimal CPAP usage may not be appropriate given that the threshold level for daily CPAP use appears to depend on the outcome measure used and may vary significantly between patients [15]. Given this variation, a better and more detailed understanding of adherence to CPAP therapy for individual patients may help to optimize delivery of CPAP therapy and related outcomes.

Available data suggest that the pattern of usage is established early in CPAP treatment and that early usage predicts later adherence [16, 17]. Understanding the pattern of CPAP usage over time is interesting because it may guide more effective interventions.

Many adherence studies focus on the first three months of CPAP treatment and this is a critical time over which to support adherence. However, CPAP usage beyond 3 months is also important because sustained benefits will only be achieved with consistent and ongoing adherence to CPAP

therapy. It is not uncommon for health-promoting behaviors to lapse over time, but the cost of supporting adherence over the long term can be prohibitive for many services. The importance of long-term interventions that help sustain health behaviors is also highlighted by study data showing significant treatment-by-compliance interactions with sleepiness [2, 13], scores on the Multiple Sleep Latency Test (MSLT) [13] and Functional Outcomes of Sleep Questionnaire (FOSQ) [2, 13], and the vitality subscale of the Short Form-36 (SF-36) [2] and cardiovascular outcomes. The American Thoracic Society recommends that CPAP adherence be monitored consistently over the long term [18]. However, there is a relative lack of knowledge about adherence to CPAP treatment after 90 days of therapy, and about potential cost-effective strategies that could be used to ensure adherence over longer time periods.

A number of techniques have been used to try and improve adherence with CPAP therapy, including patient education, supportive and behavioural interventions [19-21], peer support [20, 22-24] and clinical support [21-23, 25]. However, these can be labor intensive and therefore costly, and are difficult to sustain for patients requiring long-term therapy. Another approach that is gaining increased recognition is the use of digital health solutions such as telemedicine [26-30]. However, there is a limited amount of data on the effectiveness of digital health solutions for supporting adherence.

myAir is a theory-based, Health Insurance Portability and Accountability Act (HIPAA)-compliant mobile responsive cloud-based application that is an available option for patients using the ResMed AirSense 10 CPAP series (AirSense 10 CPAP, AirSense 10 AutoSet, AirSense 10 Elite, AirSense 10 Autoset for Her) and AirCurve 10 (AirCurve 10 ASV, AirCurve 10 VAuto, AirCurve 10 S, AirCurve 10 ST) devices. The myAir program integrates

aspects of Social Cognitive Theory (SCT) [31, 32], the Fogg Behavior Model (FBM) [33], the spirit of Motivational Interviewing [34] and the Chronic Care Model (CCM) [35-38]. Additional strategies employed by myAir to facilitate behavior change include simplifying complex tasks and information, positive reinforcement, providing encouragement, tailoring information, intervening at the right time, digital storytelling, language and self-monitoring. Mobility and connectivity also provide an opportunity for patients to access myAir and to receive messages at an opportune moment, during periods of downtime (e.g. while the patient is standing in a line) and when it would not be possible or convenient for clinicians to contact them.

This study used data from myAir to characterize CPAP usage in a large real-world population of CPAP recipients who activated the myAir component of their Airsense 10 series devices.

Methods

The myAir database was queried for records created between October 2014 and March 2015. During the myAir setup procedure patients can optionally enter the month and year that they started CPAP treatment. This allowed patients to be divided into different user groups based on their experience using CPAP prior to activation of myAir. Records for accounts that had been activated, had at least 90 days of data and had a realistic treatment start month and year specified were included in the analysis (patients with treatment start dates before 1990 were excluded).

Two different categorizations of user experience were used in the analyses: (1) brand new users (CPAP use for 0-30 days) vs. others (CPAP use for >30 days); (2) novice (CPAP use for 0-90 days), intermediate (CPAP use for >90 to 180 days), experienced (CPAP use for >180 days) and strugglers (Figure 1). Strugglers were defined users who had 0 to 30 days experience using CPAP treatment prior to activating their myAir account and <2 hours average usage in the first 14 days on myAir. Medicare calculations were completed only on the brand new users to minimize the confounding effect of experience. Days where there was no CPAP usage and days when usage was <20 minutes were considered as non-used days. Non-used days were included in calculations.

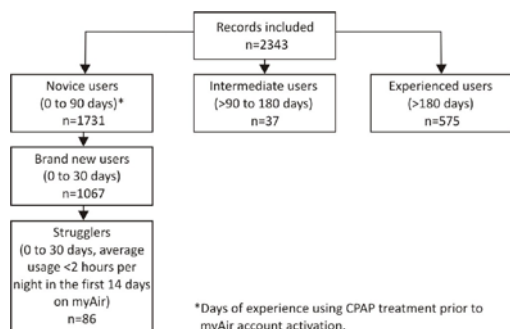


Figure 1: Study flow diagram

To determine user groupings, the myAir activation date was used as the CPAP treatment start date if the therapy start month and year matched the activation date. Otherwise, the therapy start date was assumed to be the 15th day of the month and year recorded.

The proportion of patients achieving the Medicare definition of CPAP [1] was calculated for brand new users. The earliest time that it was possible to satisfy these criteria was after 21 days of CPAP therapy. Once participants were defined as satisfying the Medicare criteria they remained in the compliant group even if CPAP usage subsequently fell below the compliance threshold at later times in treatment.

Average usage hours, intervals and thresholds, and the average number of days per week CPAP was used over the 90-day assessment period in novice, intermediate, experienced and all CPAP users were also determined based on myAir data.

Data are presented using descriptive statistics, including percentage of patients, mean and 95% confidence interval (CI), median, range, standard deviation (SD) and standard error (SE) where applicable. Comparisons between patient groups were made using t-tests, ANOVA, Chi-square tests, or Fisher's exact tests, as appropriate. SAS Version 9.3 was used for most analyses.

As a sensitivity analysis, two missing data procedures were used to evaluate the effect of blank data fields. The primary method was a conservative imputation of the missing usage hours: if CPAP usage hours were missing for a particular night, they were imputed as zero. The second method was to treat the missing values as missing; in this case the missing values were not included in calculations of means, SD, SE values and proportions.

Results

There were 2343 patients who met the inclusion criteria; 70% of participants were male, 29% were female and 1% did not disclose their gender. Novice (n=1731), intermediate (n=37) and experienced (n=575) users had 16.2±21.7 days, 121.1±21.0 days and 7.9±4.6 years of experience using CPAP treatment prior to using myAir, respectively. A total of 1067 patients were classified as brand new users and 86 patients were classified as strugglers.

Medicare adherence (brand new users)

The proportion of brand new users who achieved the criteria for Medicare adherence in 90 days was 83.9%, and 75.4% achieved Medicare adherence within 30 days. The median time to achieve Medicare adherence was 23 days (Table 1); this was similar in males and females. Eighty-six brand new users were classified as strugglers. Of these, 19.8% went on to achieve Medicare adherence in 90 days (Table 2). Female strugglers took longer than male strugglers to achieve Medicare adherence.

Adherence and device usage by user group.

The proportion of patients using CPAP for ≥ 4 hours for at least 70% of days over a 90 day period was significantly higher in the experienced user group compared with novice ($p < 0.0001$) and intermediate users ($p = 0.02$) (Table 3).

In addition, participants in the experienced user group used CPAP more regularly than both novice and intermediate users. This was reflected in higher usage hours in experienced compared with novice users, with significant differences between user groups; experienced users had significantly higher mean usage than both novice and intermediate users (Table 3). Only 19.5% and 32.2% of novice and experienced patients respectively used CPAP for > 20 minutes every day.

Table 1: Medicare adherence in brand new users

	Gender		All Subjects (N=1067)
	Male (N=708)	Female (N=349)	
Number of days to achieve Medicare adherence			
Mean (SE)*	36.3 (0.96)	36.0 (1.33)	36.3 (0.78)
Median (95% CI)	23.0 (23.0, 23.0)	23.0 (23.0, 24.0)	23.0 (23.0, 23.0)
Subjects with adherence, n (%)			
21 to 30 days	533 (75.3)	262 (75.1)	804 (75.4)
>30 to 60 days	40 (5.6)	20 (5.7)	60 (5.6)
>60 to 90 days	20 (2.8)	11 (3.2)	31 (2.9)
Medicare non-adherent	115 (16.2)	56 (16.0)	172 (16.1)
Medicare adherent	593 (83.8)	293 (84.0)	895 (83.9)

CI, confidence interval; SE, standard error.

* The mean survival time and its SE were underestimated because the largest observation was censored and the estimation was restricted to the largest event time (90 days).

Table 2: Medicare adherence in brand new users defined as strugglers

	Gender		All Subjects (N=86)
	Male (N=53)	Female (N=32)	
Number of days to achieve Medicare adherence			
Mean (SE)*	68.8 (1.38)	82.5 (2.80)	81.4 (1.65)
Median#	>90	>90	>90
Subjects with adherence, n (%)			
>30 to 60 days	9 (17.0)	3 (9.4)	12 (14.0)
>60 to 90 days	2 (3.8)	3 (9.4)	5 (5.8)
Medicare non-adherent	42 (79.2)	26 (81.3)	69 (80.2)
Medicare adherent	11 (20.8)	6 (18.8)	17 (19.8)

Strugglers were defined as having average CPAP use of < 2 h/night in the first 14 days on myAir.

* The mean survival time and its SE were underestimated because the largest observation was censored and the estimation was restricted to the largest event time (90 days).

Table 3: CPAP compliance and usage by category of user experience

	User group		
	Novice (N=1731)	Intermediate (N=37)	Experienced (N=575)
Average usage ≥ 4 hours for at least 70% of nights, n (%)*			
	1228 (70.9)	25 (67.6)	475 (82.6)ab
Average weekly usage, n (%)			
0 days	28 (1.6)	3 (8.1)	9 (1.6)
>0 to <4 days	180 (10.4)	5 (13.5)	32 (5.6)
≥ 4 to <7 days	1185 (68.5)	19 (51.4)	349 (60.7)
Every day	338 (19.5)	10 (27.0)	185 (32.2)
Average nightly usage, hours (mean\pmSD)			
	5.6 \pm 2.21	5.4 \pm 2.58	6.5 \pm 2.04cd

SD, standard deviation.

* Calculated over 90 days; this differs from Medicare adherence because the criteria needs to be satisfied for the entire 90 day period rather than during any consecutive 30 day period during the first 3 months of initial usage. ap < 0.0001 vs novice users; bp=0.02 vs intermediate users; cp < 0.0001 vs novice users; dp=0.01 vs intermediate users.

Overall, 57.1% of CPAP recipients used their device for ≥ 6 hours/night. The proportion of patients using CPAP for longer time periods was higher for experienced users (Table 4). Exclusion of missing usage data had only a minimal effect on these values.

Discussion

The main finding of this study was that a high proportion (83.9%) of brand new CPAP users who used standard care and the ResMed myAir self-management application achieved Medicare adherence in the first 90 days of CPAP treatment. The median time to achieve Medicare adherence was 23 days. This suggests that the myAir digital health solution may have a positive effect on adherence to CPAP therapy.

This study also found that experienced users are generally using treatment for longer and more frequently compared with novice and intermediate users, suggesting that these factors may be associated with long-term adherence for particular cohorts of CPAP users. One possible mechanism is that patients using treatment for longer and more often are more likely to notice the benefits of treatment which helps motivate continued use. Another possible reason is that with time, persistence and practice, patients become more skilled at using CPAP treatment, also supporting longer and regular usage. Also, some patients will quit CPAP treatment over time meaning that the experienced user group is less likely to include those struggling on CPAP treatment, thus increasing average usage hours in the experienced group. For these reasons it is likely that the usage profile of experienced, habituated and probably motivated users in this study represents a best-case scenario achieved with a broad range of US-based standard care.

There have been few studies looking at supporting CPAP usage over the longer term. One of these compared the effects of high-touch intensive and standard follow-up on CPAP adherence over a 24-month period in 3100 Mediterranean patients with newly-diagnosed moderate-to-severe sleep apnea [39]. The standard care approach in this study was relatively comprehensive by world standards, and included a 15- to 30-min follow-up visit at the sleep clinic during which compliance data were downloaded from the device and discussed with the patient, and side

effects that could lead to suboptimal compliance were addressed. Any uncertainty about a patient's compliance or willingness to continue on CPAP therapy was discussed with a physician and steps undertaken to resolve barriers to compliance. In addition to these measures, the high-touch intensive intervention group also received multiple simultaneous strategies such as education, role models, authority figures, spousal involvement, monitoring, regular follow-up, trouble shooting, home visits, telephone calls, lectures, counselling to reduce perceived barriers to CPAP use, sleep diaries, and access to a 24-hour consultation telephone line. Use of these labour-intensive approaches to maintaining or improving adherence resulted in 79.8% of patients in the standard group and 92.8% of those in the intensive group using CPAP regularly for ≥ 4 hours per night on at least 70% of days. In the current study, the addition of the low-touch myAir digital health solution resulted in 70.9% of novice CPAP users adhering to CPAP for ≥ 4 hours per night on 70% of days; the corresponding rate for experienced users was 82.6%. In the Mediterranean study [39], mean \pm SD hours of CPAP use calculated over a 24-month period were 5.2 \pm 2.2 hours in the control group and 6.9 \pm 1.8 hours in the intervention group. This myAir study found that the mean \pm SD hours of CPAP use over a 3-month period in novice users was 5.6 \pm 2.21 hours and in experienced users it was 6.5 \pm 2.04 hours. These rates compare favorably with those achieved in the intensive intervention trial, and were obtained with markedly lower time and resource requirements. This suggests that myAir may be a cost effective and sustainable addition to standard care that can improve adherence to CPAP therapy.

In this study, 53.2% of novice users and 69.2% of experienced users were sleeping on CPAP for ≥ 6 hours/night. There was a difference of 16% between experienced and novice users, and these CPAP usage rates are substantially higher than those reported in previous studies where 41.7% and 45.1% of participants used CPAP for ≥ 6 hours/night [2, 13]. Given the dose-response relationship between CPAP usage and normalization of neurocognitive and cardiovascular outcomes it would appear that a high proportion of patients receiving CPAP treatment in the short to longer term may continue to have excessive daytime sleepiness, poor Functional Outcomes of Sleep Questionnaire (FOSQ) and vitality scores, and also potentially elevated cardiovascular risk because they are

Table 4: Nightly CPAP usage by user group

	User Group			All Subjects (N=2343)
	Novice (N=1731)	Intermediate (N=37)	Experienced (N=575)	
≤ 2 hours	166 (9.6%)	6 (16.2%)	28 (4.9%)	200 (8.5%)
2–4 hours	185 (10.7%)	4 (10.8%)	34 (5.9%)	223 (9.5%)
4–5 hours	181 (10.5%)	1 (2.7%)	41 (7.1%)	223 (9.5%)
5–6 hours	278 (16.1%)	7 (18.9%)	74 (12.9%)	359 (15.3%)
6–7 hours	388 (22.4%)	6 (16.2%)	120 (20.9%)	514 (21.9%)
≥ 7 hours	533 (30.8%)	13 (35.1%)	278 (48.3%)	824 (35.2%)

not using CPAP enough. This reinforces the importance of short- to long-term cost-effective interventions that enable early intervention and help to facilitate and sustain positive health behaviors.

The current study has a number of strengths. It includes a large sample overall and the number of blank data fields was very low (<0.2% of usage) and did not significantly influence the results of the analysis. The low rate of missing data was probably due to the reliable connectivity of the AirSense 10 series devices and increases the accuracy of the study findings. Even when taking a conservative approach and replacing blank data fields with '0', adherence remained good.

There are also a number of limitations that need to be taken into account when interpreting the results of this study. Patients using myAir are likely to be more engaged and motivated to treat their sleep apnea, and higher CPAP usage would be expected in a more motivated group. Another factor that might have influenced the study findings is that Day 1 on myAir may not correspond to Day 1 on CPAP treatment. Patients registering for myAir after a few weeks of CPAP treatment may have had the opportunity to work through major treatment issues with their clinicians and this could account for the high level of usage seen. The reliance on patients to enter data accurately into myAir (e.g. CPAP start month) is another factor that might introduce bias into the study findings.

This study showed that patients using myAir during CPAP therapy showed good adherence over the first 90 days of treatment. Adherence to CPAP therapy was better in experienced users than in novice users. Overall, the results suggest that myAir is a simple, easy-to-use and sustainable option that may lead to improved compliance in patients receiving CPAP.

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