Empowering the sleep apnea patient

How online patient engagement tools improve adherence to treatment

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Contents

Summary and highlights

Sleep apnea is a condition that affects more than 3 in 10 men and nearly 1 in 5 women[1]. It occurs when an individual stops breathing for a period of at least 10 seconds while asleep, and when this appears 5 times or more per hour. The condition is associated with comorbidities including heart failure, diabetes, and hypertension. The gold standard treatment for sleep apnea is continuous positive airway pressure (CPAP) therapy, which keeps the airway open to prevent apnea events from occurring. Research has shown that consistent use of CPAP therapy is associated with improved health outcomes.

Increased awareness and screening of selected risk groups is triggering a rapid increase in the number of sleep apnea patients across Europe. At the same time, resources allocated to sleep clinics are limited, causing a difficult situation for many clinics.

Telemonitoring has had considerable impact on many clinics and home care providers in managing sleep apnea patients. Mostly in how they work and treat patients and often resulting in the clinics and home care providers becoming more time-efficient, typically with 30-50% time savings[2]. They manage to treat more patients, as telemonitoring enables clinics and home care providers to treat patients differently according to their specific needs. Examples are low-touch and "virtual" consultations with some patients, and frequent interventions with other patients.

Another use of telemonitoring is the possibility to track and share CPAP usage information with the patients themselves. There is evidence that giving patients access to information about their own treatment leads to better adherence[3], and also that automated, trigger based email- or text messages have the same positive effect as traditional human interventions[4].

And interventions matter. Studies have shown that different types of interventions increased daily usage between 30 minutes and 1h30 minutes[5]. There is a common belief in the industry that patient engagement is one of the key elements to successful treatment – and reminders, education and behavioural support are all intended to empower the patient and facilitate successful treatment.

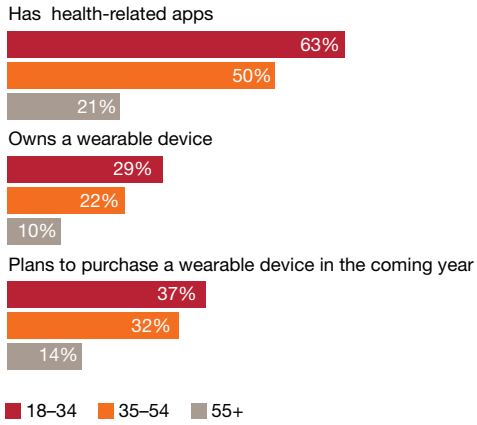
Most patients today have a PC or smartphone with internet access. This is also true for older patients indicating technology is becoming prevalent in all patient groups, not only among the young and technology savvy. Yet, very few patients today use the technology they have at home as a tool in treating their sleep apnea, mainly because it has not been possible before CPAP devices were connected to telemonitoring. This has changed with the introduction of myAir, which is an online web-page where patients can track their CPAP treatment. myAir also provides notifications to alert the user to a problem or to positively reinforce behavior.

This paper aims to test a simple hypothesis formulated as:

"Patients that use myAir show significantly and measurably better adherence and usage than other patients."

1. Peppard et al. Increased Prevalence of Sleep-Disordered Breathing in Adults. Am J Epidemiol. 2013 (5.17)
2. Effects of Telemonitoring on treatment of sleep-disordered breathing, PwC 2015
3. Kuna et al, 2015
4. Munafo et al, 2016
5. Wozniak et al, Cochrane Publications, 2014

Respondents' attitudes towards mobile solutions – by age group



This paper presents the results of a study of over 23,000 patients in Germany, the UK and Ireland, approximately 1,800 of which have registered for myAir. The study aims to understand if and how myAir patients behave differently from other patients with regards to their PAP device usage. We want to understand if access to treatment data and being supported by myAir's trigger-based and automatic "interventions" have an effect on patients' device usage and treatment adherence.

We have looked at new and established patients in both countries. Patients who registered for myAir show significant increased daily device usage and improved adherence to therapy.

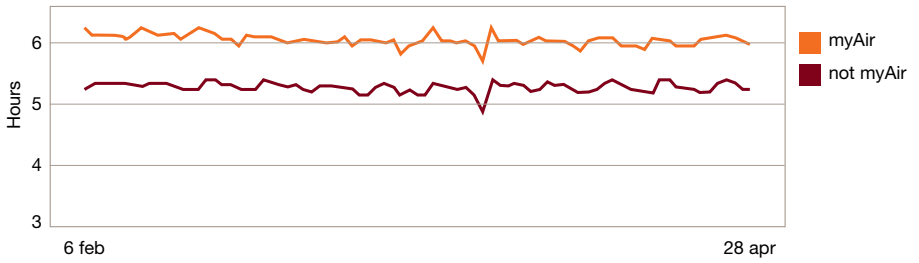
The result: myAir patients show significantly better daily usage, as well as higher adherence, than other patients (P<0.0001).

- The increase in daily device usage is 46 minutes on average over the studied 3 months period for all patients. myAir patients use their therapy device 6h 1m on average, while other patients use their therapy device only 5h15minutes on average per night
- First week average adherence for new patients is 76% for myAir patients vs 71% for other patients

myAir patients use the device on average 46 minutes longer every night compared to other patients.

Daily average device usage

Both countries, all patients, 6 February to 28 April 2016.



N=23,000 non-myAir, 1,800 myAir. P-value <0.0001 for entire model; P-value <0.0001 for myAir patients; P-value 0.024 for other patients.

myAir patients also have higher adherence rates than other patients. Again, true for both countries and all clinics and home care providers.

myAir patients have higher adherence than other patients, also over time

Weekly average adherence (minimum 4 hours of daily use)

Both countries, new patients, calibrated to day 1, first 8 weeks

% of patients	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
myAir	76%	81%	79%	78%	79%	78%	79%	81%
Not myAir	71%	70%	68%	67%	67%	66%	67%	68%
Difference	5 ppts	11 ppts	11 ppts	11 ppts	12 ppts	12 ppts	12 ppts	13 ppts

Differences are seen in the first week of treatment and remain over time. In addition to helping patients achieve better usage, we have some ***early indications that the "empowered" patients are less prone to call the clinic for help***. Or as one clinic puts it:

"In the last few months since we started promoting myAir, we've seen a significant decrease in the number of incoming phone calls"

Introduction

The number of patients diagnosed with sleep-disorded breathing is growing dramatically across Europe, putting a strain on sleep clinics which face the challenge to treat additional patients while caring for the patients already on treatment.

Sleep-disordered breathing encompasses a range of conditions characterised by abnormal breathing during sleep. Prevalence of sleep-disordered breathing is estimated at c. 26%[1] of the total adult population, indicating a massive number of c. 70 million potential patients suffering from sleep-disordered breathing in the EU28 area. It should be noted that a significantly higher prevalence is seen among obese and the male population in the older age groups.

The prevalence of mild to severe SDB was approximately 2-fold higher in older men than in younger men (37% vs. 18%, respectively); among overweight women, the prevalence was approximately 5-fold higher in older women than in younger women (20% vs. 4%, respectively). However, it is worth mentioning that far from all patients currently receive treatment.

The most common form of sleep-disordered breathing is obstructive sleep apnea and is thus the focus of this paper.

What is OSA?

Obstructive sleep apnea (OSA) occurs when the relaxation of the throat muscles obstructs airflow for more than 10 seconds at a time. The severity is usually measured as the Apnea-Hypopnea Index (AHI). The AHI is the number of apneas and/or hypopneas per hour of sleep (or study time).

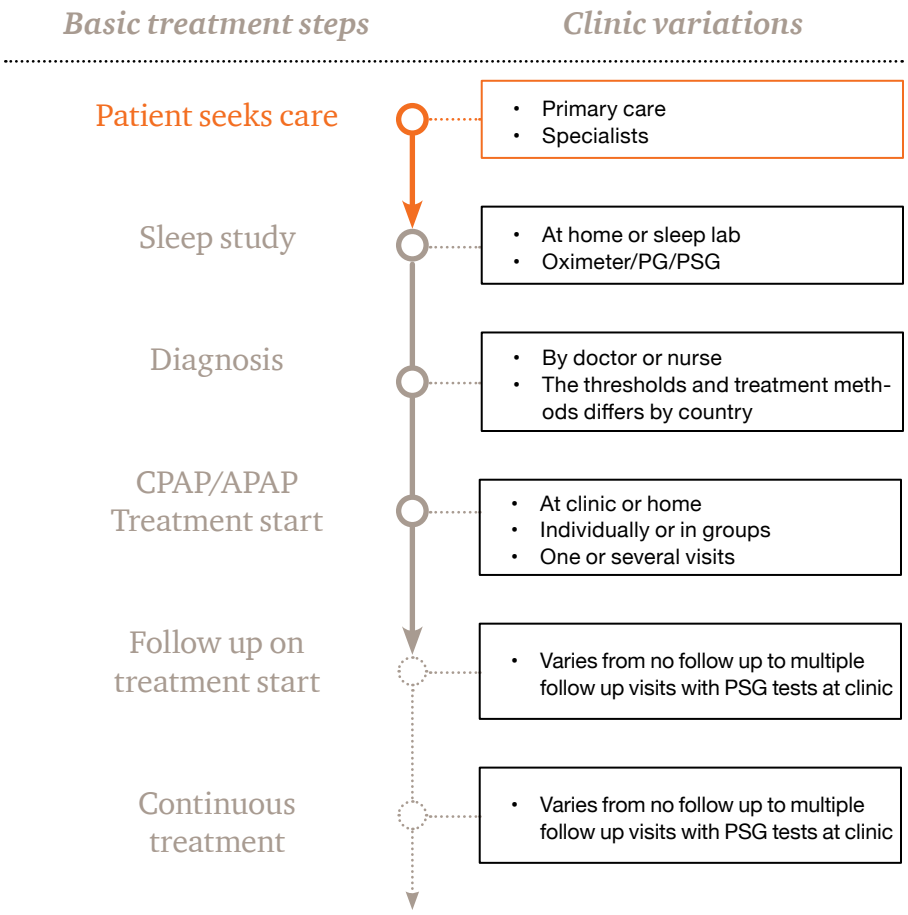
1. Peppard et al. Increased Prevalence of Sleep-Disordered Breathing in Adults. Am J Epidemiol. 2013 (5.17)

Treatment of sleep apnea

Treatment of sleep apnea is normally initiated when the patient seeks care, either for symptoms directly related to sleep apnea or symptoms related to diabetes, heart diseases etc. When sleep apnea is suspected, a sleep study is performed to determine whether the patient is in fact suffering from the medical condition and what treatment method is suitable. The methods of conducting sleep studies differs between countries and clinics.

When a patient is diagnosed with sleep apnea a treatment method is prescribed. This paper exclusively studies positive airway pressure therapy as it is the most commonly prescribed treatment. A device and a mask that deliver constant (CPAP) or automatically varying pressure (APAP) to patients during their sleep are used in positive airway pressure therapy. Other treatment methods include oral appliance therapy, surgery and weight loss.

When a patient has been prescribed a CPAP/APAP device he or she visits the clinic for a treatment start appointment. Most clinics then schedule several follow up appointments during the first year to ensure that the patient is responding to the treatment. The first weeks of treatment are identified as the crucial time during which patients either drop out of therapy or stay adherent to the treatment. **Clinics and home care providers across Europe estimate that 60-70% of patients stay on the treatment after the first 6 months,** but reliable statistics are not available as many clinics and home care providers do not systematically follow up their patients and because treatment pathways differ between countries.



Treatment and adherence

Adherence – whether a patient uses the prescribed treatment sufficiently to achieve the best possible results – is a major concern for sleep treatment professionals. Much thought and effort goes into finding ways to support patients with education, technical support, regular and/or ad-hoc interventions, etc.

Many clinics and home care providers work to increase the motivation of their patients to follow their therapy. Some encourage their patients to keep a diary to track progress of how much better they feel, others have group sessions with patients to foster an environment of positive social support. Many clinics and home care providers spend considerable time explaining how CPAP treatment works, and on showing and describing how to use and adjust masks and machines - so much, that they are concerned with overload:

"A patient will not be able to remember more than a third of what we tell them"

Recent years' introduction of telemonitoring has given clinics and home care providers a tool to identify and proactively intervene to help patients starting CPAP treatment. An interesting example of how telemonitoring helps is a clinic in the UK that says:

"We do group treatment starts, which saves us a lot of time. Obviously, this format does not work for all patients, and they may not be able to fully understand the usage instructions. Thanks to telemonitoring, we typically see, already during the first couple of days, which patients are struggling with treatment, and we call them to help them, individually."

Anecdotal evidence suggests that intervening early to solve problems has helped many patients stay adherent to using CPAP treatment. Telemonitoring also means improvements for patients, with typically fewer trips to the clinic or home care provider, and a positive understanding of being "monitored" by their nurse, physician or home care provider. All in all, telemonitoring has resulted in more efficient work for clinics and home care providers, with improved and more patient centric care models.

Up to now, telemonitoring has mainly helped professional users in clinics or home care providers to streamline processes and operate more efficiently. A natural next step is to involve the patient in his or her own treatment to a higher degree than today.

myAir is a personalised therapy management tool for patients that encourages them to start and continue on therapy and resolve basic questions to increase their comfort. myAir claims to maximise adherence and drive operational efficiencies.

A belief that much of treatment success depends on the patient himself is common among sleep apnea practitioners, and much effort is going into supporting patients. Many professionals say motivation makes all the difference, "you can lead a horse to water but you cannot make it drink", or "it is very much dependent on the patient if he really wants to improve his health condition".

myAir is a tool built specifically to enable the patient to track and improve treatment and device usage, through engaging the patient in his own treatment, or by identifying problems and providing solutions.

This paper presents the results of a study of over 23,000 patients in Germany, the UK and Ireland, approximately 1,800 of which have registered for myAir. The study aims to understand if and how myAir patients behave differently from all other patients.

This paper aims to test a simple hypothesis formulated as:

"Patients that use myAir show significantly and measurably better adherence and usage than other patients."

Previous studies on patient engagement and sleep apnea

In addition to interviewing clinics and home care providers, we have read and referenced a number of other studies on patient engagement and adjacent subjects. This chapter summarises these other studies, and some of these sources will also be used as commentary throughout the report.

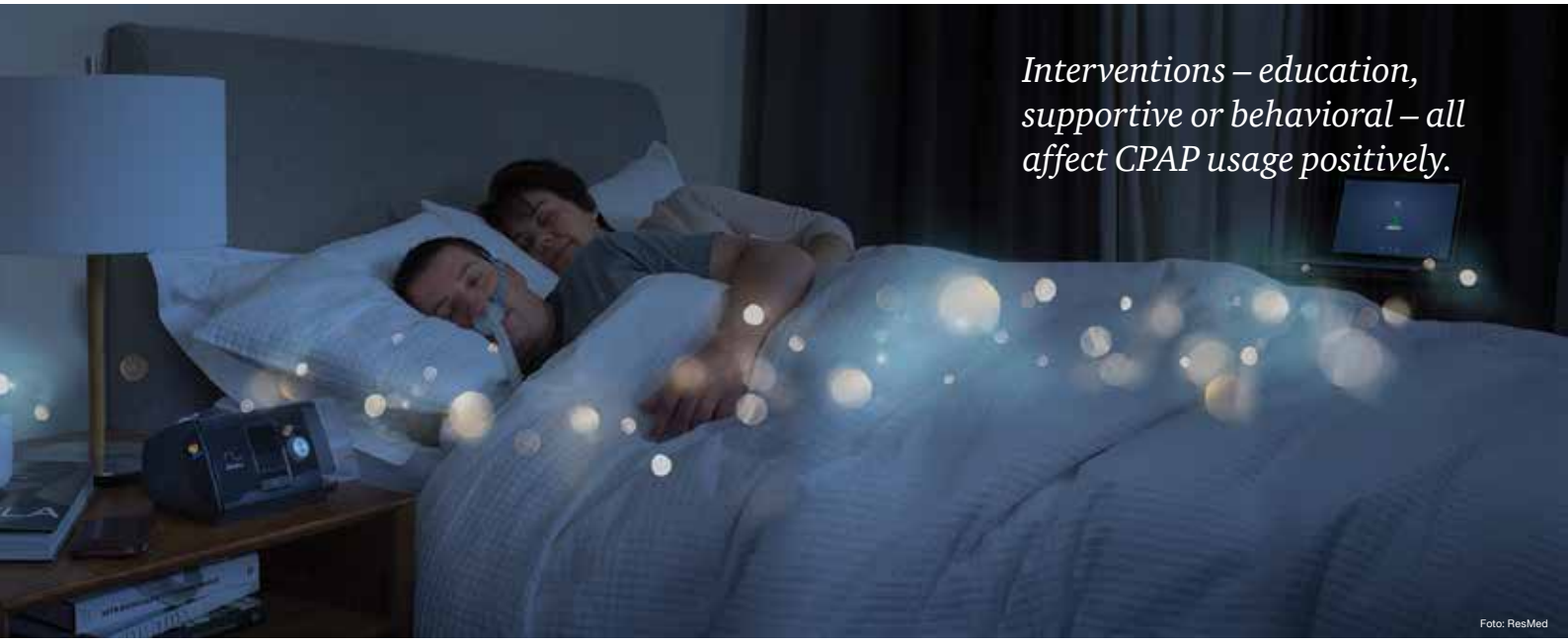
Study on how interventions can improve usage

Can interventions improve CPAP usage?

Educational, supportive and behavioural interventions to improve usage of continuous positive airway pressure machines in adults with obstructive sleep apnoea, Wozniak DR, Lasserson TJ, Smith I, Cochrane Publication, 2014

This systematic review investigated three different kinds of interventions, and how they influence machine usage. The authors conclude that:

"In combining the results from all trials, we found that all three types of interventions increased CPAP usage to varying degrees. Ongoing supportive interventions were more successful than usual care in increasing CPAP usage by about 50 minutes per night. Educational interventions resulted in a modest improvement of about 35 minutes per night. Behavioural therapy increased machine usage by just under one and a half hours per night."



Interventions – education, supportive or behavioral – all affect CPAP usage positively.

Foto: ResMed

Study on telehealth

Can interventions be automated, and based on pre-set triggers, and built on daily telemonitoring of patients' device usage?

A telehealth program for CPAP adherence reduces labor and yields similar adherence and efficacy when compared to standard of care, Dominic Munafo, William Hevener, Maureen Crocker, Leslee Willes, Sarah Sridasome, Ma'an Muhsin, 2016

This is a study looking into whether telehealth/telemonitoring can help reduce the workload on the clinics, and if patients' adherence to treatment differs depending on the method of care they receive: standard of care (SOC) where patients received scheduled calls, or telehealth (TH) where patients received web-based automated text messages or emails triggered by preset conditions. The study followed 122 patients in total.

Munafo et al found no statistically significant differences in daily CPAP usage or Medicare adherence - but all trends favoured the TH group. Munafo et al conclude that:

"Use of a web-based telehealth program for CPAP adherence coaching significantly reduced the coaching labor requirement compared with SOC, while maintaining similar adherence and effectiveness."

Study on web-based access for patients to their own data to improve usage

Can providing access to patients' own usage data have an effect on daily usage?

Web-Based Access to Positive Airway Pressure Usage with or without an Initial Financial Incentive Improves Treatment Use in Patients with Obstructive Sleep Apnea, Kuna ST, Shuttleworth D, Chi L, Schutte-Rodin S, Friedman E, Guo H, Dhand S, Yang L, Zhu J, Bellamy SL, Volpp KG, Asch DA, SLEEP 2015

This study tested if providing patients with daily web-based access to their CPAP usage improves adherence and functional outcomes. The study followed 138 patients over a three month period. The patient group with web-based access were divided into two sub-groups, one of which received a small financial incentive for each day they logged into the website.

Kuna et al. says

"Average daily use in the first week was 4.7 +/- 3.3 hours in the usual care group compared to 5.9 +/-2.5 h and 6.3 +/- 2.5 h in the Web access groups with and without the financial incentive, respectively".

And they conclude:

"Positive airway pressure adherence is significantly improved by giving patients Web access to information about their use of the treatment"

Average first week daily usage in the three groups studied by Kuna et al 2015

Kuna et al. study: Usage first week	Average usage	Std deviation
Web-access	6h18m	+/- 2h30m
Web-access + financial incentive	5h54m	+/- 2h30m
Usual care	4h42m	+/- 3h18m

Study on digital self-monitoring

Can myAir have a positive effect on adherence to CPAP therapy?

"PAP adherence was significantly improved for patients that used the myAir application"

A propensity-adjusted comparative analysis of PAP adherence associated with use of myAir, Maureen Crocker, Sue Lynch, Leslee Willes, Colleen Kelly, Adam Benjafield CHEST Journal, 2016

This retrospective, observational study included 128,037 US patients. myAir users and non myAir users were matched on propensity scores to minimize risk of potential bias. Patients in both groups were effectively treated with PAP therapy over the 90 days the study included.

There was a significant improvement in the percent of patients that reached US Medicare adherence within 90 days (87.3% for myAir patients vs. 70.4% for AirView-only patients, with a p value less than 0.0001), showing a 16.9% improvement in adherence. Additionally mean daily PAP usage was also significantly higher in myAir patients compared to AirView-only (5h54min hours vs. 4h54min, respectively).

The study was presented on October 26, 2016, at the CHEST Annual Meeting in Los Angeles.

Take-aways from these studies

Key take-aways from the four studies are as follows:

- Interventions help improve CPAP adherence anywhere from 35 minutes to over 1h30 minutes;
- Trigger-based and automated text or email messages based on telehealth leads to at least the same CPAP usage as traditional scheduled follow-up calls but with much less effort from the clinicians;
- Providing patients with web-based access to their own usage data improves daily usage more than 1h in the first week;
- American myAir users show statistically better usage and treatment than other patients – myAir seems to be an efficient way to drive adherence.

This paper will address some of the limitations and concerns identified in the other studies; namely, we will study a large sample (over 23.000 patients); we will have a control group (patients with and without myAir), and we will cover both established and new patients.

Description of studied patients

Basic information on population and usage

On average, the studied patients use the device just over 5 hours per night, with typically some 10 minutes more usage on the best night (Sunday) than on the worst night (Saturday).

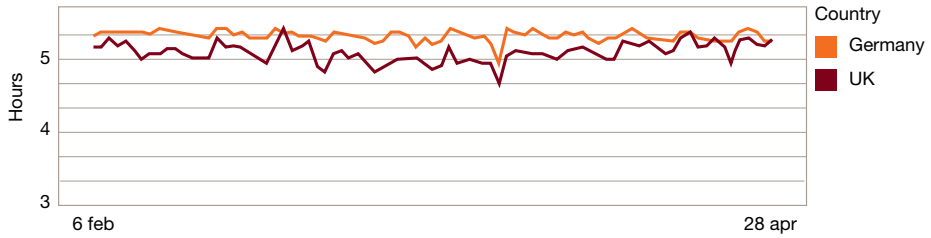
Average daily device usage

Both countries, all patients, 6 February to 28 April 2016

N=23,000 patients

Average daily device usage by country

Both countries, all patients, 6 February to 28 April 2016



N=21,000 patients in Germany, 2,500 patients in the UK. Country factor significance: P<0.0001

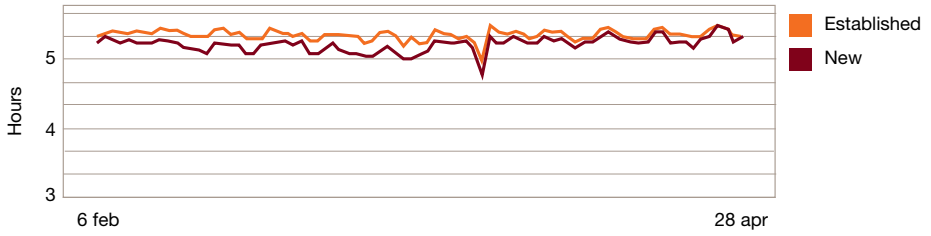
The graph **above** shows the difference in device usage between UK/Ireland and Germany: the difference is 15 minutes on average over the entire studied period. Possibly, the difference can be explained by stricter adherence measurements in Germany. One German home care provider representative is of the opinion that:

"Many of our patients have employers that demand proof of adherence. Others have to reach at least a threshold to receive continued support from their insurance companies."

The graph **below** shows the difference between new and established patients. The difference is smaller than the one observed when comparing the countries. On average it is only 8 minutes over the entire period.

Average daily device usage by patient type

Both countries, new and established patients, 6 February to 28 April 2016



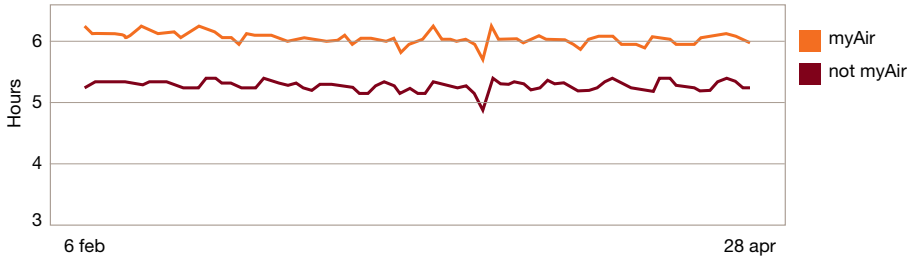
N=15,000 established patients, 2,000 new patients. New/established factor significance: P<0.0001

myAir patients use the device 46 minutes more every night

When looking at the difference between myAir users and other patients, we can draw an interesting conclusion: a large and significant difference is observed. The daily use difference is 46 minutes over the entire period. The difference between the groups is significant at $P<0.0001$.

Average daily device usage by myAir patients / non myAir patients

Both countries, all patients, 6 February to 28 April 2016



N=23,000 non-myAir, 1,800 myAir. myAir / not myAir factor significance: P<0.0001

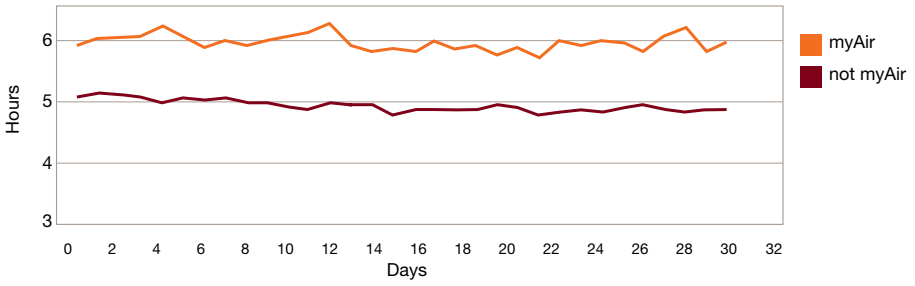
Since we know there are regulatory differences between UK and Germany that may affect behaviour, and because there is a significant difference in the average device usage between the countries, we will look closer into patients' behaviour in Germany and the UK separately.

Germany

The graph below show the average daily usage for German patients, split into the two patient groups of myAir users, and non-users. There is a significant difference in usage between the groups. myAir patients use the device alsmost 6 hours per night, while the non-myAir group only uses the device just under 5 hours per night. The difference is 57 minutes (5h53m and 4h56m respectively).

Average daily usage first month by myAir / non myAir patients

Germany, new patients, data calibrated from day 1



N=4,627, whereof 251 myAir. myAir / not myAir factor significance: P<0.0001

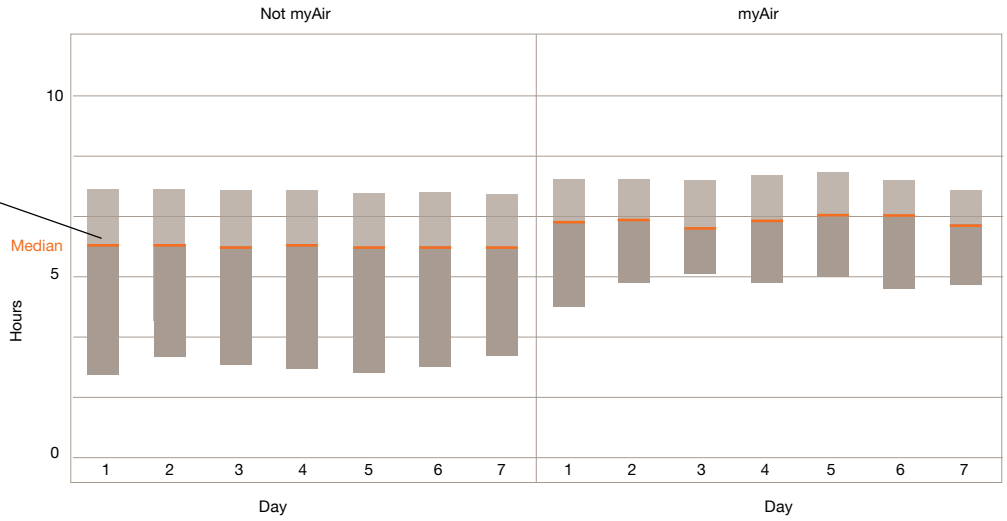
A still more detailed look, through a Box-whisker diagram, of the first 7 days shows that the myAir group has a more consistent behaviour – with less variance within the group, and a better lowest level of device usage.

Daily use days 1-7, box-plot by myAir / non-myAir

Germany, new patients, data calibrated from day 1

The upper and lower box limits mark the 25th and the 75th percentiles; meaning 50% of all the patients' daily usage is within the box; with the "worst" 25% of patients below the box, and the "best" 25% of patients above the box.

The median is the middle point of all the data for that day



N=4,627 non-myAir, 251 myAir

The left hand side shows patients not using myAir; the right hand side shows patient using myAir. This picture confirms what we already suspected: the myAir group does "better" than the other patients, already from the first days of treatment. It is also noticeable that the lower whisker is above zero (40-60 minutes) for myAir patients already from day 2.

A clinician in Germany confirms that:

"A typical pattern is that the patient's behaviour in the first days and weeks are strongly indicative of future adherence"

Adherence

Average daily use is one aspect of the treatment. Adherence – also called compliance or minimum daily use – is another.

We define adherence as minimum 4 hours of daily use. We measure adherence on a day-by-day basis, or as an average over a time period. Consequently a patient is or isn't adherent each single night. The therapy is efficient if the patient has obtained a stable level of usage above the adherence threshold.

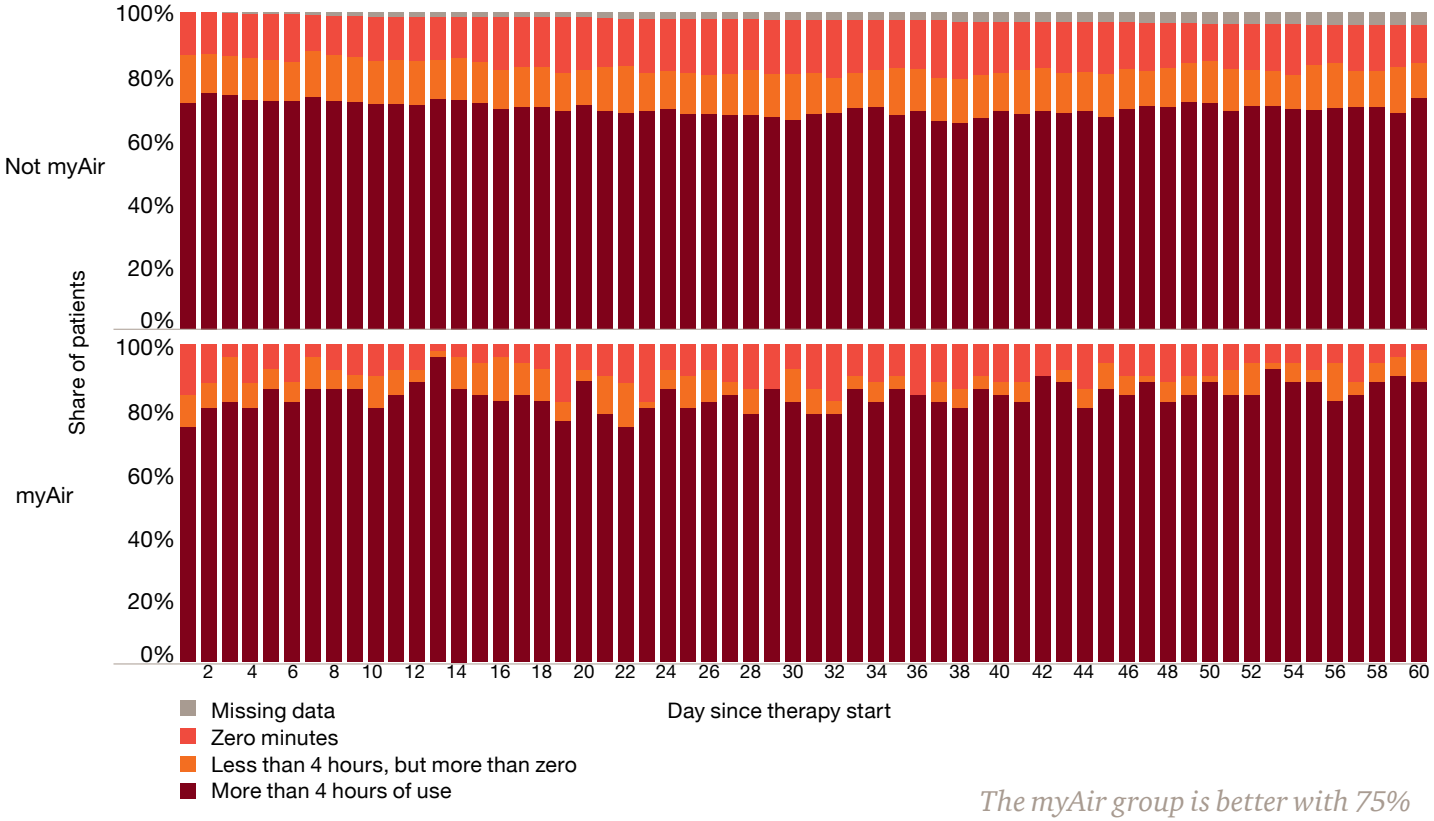
Weekly average adherence (minimum 4hours of daily use)
Germany, new patients, Calibrated to day 1; first 8 weeks

Adherence % of patients	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
myAir	81%	87%	82%	81%	83%	84%	85%	87%
Not myAir	73%	72%	70%	68%	68%	67%	69%	70%
Difference	8 ppts	15 ppts	12 ppts	13 ppts	15 ppts	17 ppts	16 ppts	17 ppts

Again, the myAir group is better with 81% of patients being adherent in the first week, rising to 87% over 8 weeks. This is compared to all other patients starting with 73%, and ending after 8 weeks at 70%.

Daily adherence (minimum 4 hours of daily use)

Germany, new patients, Calibrated to day 1; first 8 weeks, missing data excluded



The myAir group is better with 75% of patients in adherence in the first day, rising to 80% in the first week of treatment

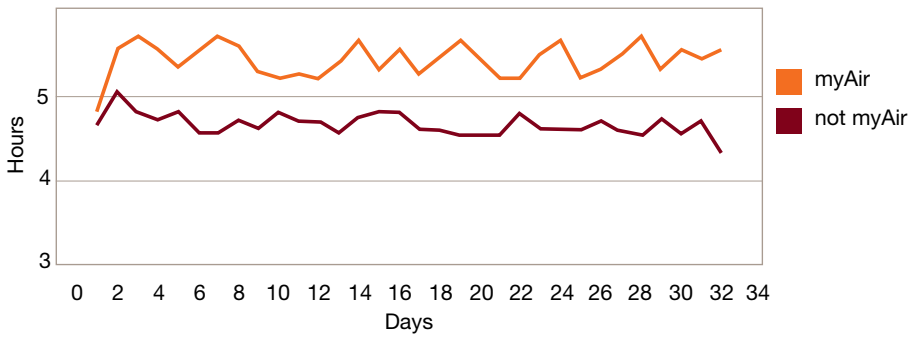
The UK

Usage

The group of **new** patients in the UK, split into myAir users and all others, shows there is a significant difference between the two groups, with the myAir patients at 5h30m on average, and the other patients using the device 4h43m on average. A difference of 47 minutes per night.

Average daily usage first month by myAir / non myAir patients

UK, new patients, data calibrated from day 1



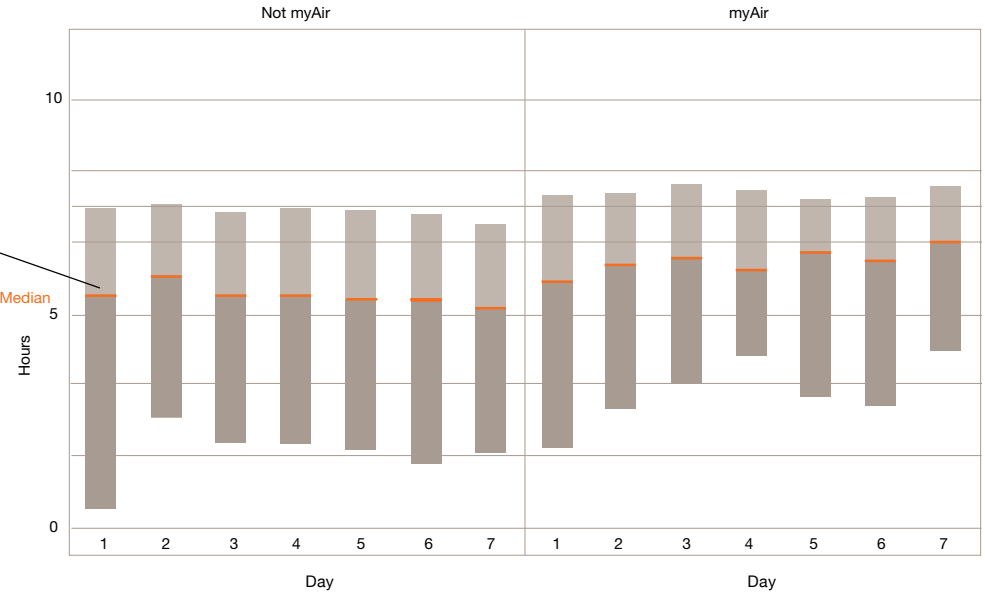
N= 569 in total, whereof 119 with myAir. myAir / non-my air P<0.0001

A Box-whisker diagram of the first 7 days shows that the myAir group has a more consistent behaviour – with less variance within the group.

The left hand side shows patients not using myAir; the right hand side shows patient using myAir. This picture confirms what we already suspected: the myAir group does "better" than other patients, already from the first days of treatment. Significant is also that the median value increases between day 1 and day 7 for the myAir group; but it decreases day by day for the other group.

The upper and lower box limits mark the 25th and the 75th percentiles; meaning 50% of all the patients' daily usage is within the box; with the "worst" 25% of patients below the box, and the "best" 25% of patients above the box.

The median is the middle point of all the data for that day



Adherence

Difference in weekly average adherence (minimum 4hours of daily use) myAir/non myAir

UK, new patients, Calibrated to day 1; first 8 weeks, missing data excluded

Adherence % of patients	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Difference	12 ppts	17 ppts	19 ppts	18 ppts	16 ppts	11 ppts	18 ppts	19 ppts

Because of the reimbursement models in Germany with insurance companies demanding 4 hours PAP usage for continued financing of treatment, all clinics and home care providers use the same instuctions and demand the same behaviour from all their patients. This shows in consistent levels of adherence for German home care providers.

In the UK, it is different with no common "standard" for adherence targets – resulting in strong variations between different clinics. However, the difference between myAir and non myAir patietns is stable and similar across all studied clinics.

Similarly to Germany, the myAir patient group shows 11-19 ppts better adherence than other patients.

Case study:

Patient engagement in Manchester

About the hospital and Sleep Clinic

The sleep clinics in the University Hospital of South Manchester (UHSM) under the leadership of David Jones have transformed their entire operations in the last couple of years. Currently, the sleep department manages over 6,000 patients, and every year 1,000 new patients are started on treatment.

The largest clinic – in Wythenshawe Hospital – is quite advanced in the use of telemonitoring for sleep apnea treatment. For instance, the clinic monitors all new patients for the first week and intervenes with supporting phonecalls if the patients have not successfully used the CPAP device. Also, the clinic strives to minimise unnecessary travel and has many consultations via Skype and phone, enabled by the telemonitored data available to the consultants.

myAir patients

Naturally, UHSM was one of the first clinics to start encouraging their patients to use myAir, which they did in autumn 2015.

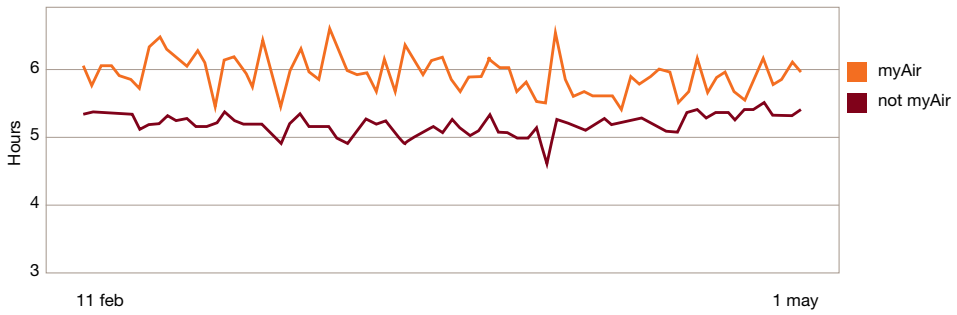
"My team informs about myAir in the group set-up sessions as part of the regular briefing instructions. There's also a myAir brochure in the box containing the CPAP device" explains David.

"I would expect much higher adherence from an engaged patient than from other patients"

David Jones,
Sleep manager at UHSM

Average daily usage myAir / non myAir patients

Manchester, all patients



N= myAir 80, not myAir 700, P<0.0001

In UHSM, as in all other studied clinics, the myAir patients are doing significantly better than the other patients: We see a 40-50 minutes better daily usage for the group of patients that have registered for myAir.

Also regarding adherence, the myAir patients do better.

Weekly average adherence (minimum 4 hours of daily use)

Manchester, new patients, Calibrated to day 1; first 8 weeks

Adherence % of patients	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
myAir	78%	79%	76%	79%	76%	65%	78%	78%
Not myAir	63%	65%	66%	67%	67%	67%	63%	62%
Difference	15 ppts	14 ppts	10 ppts	12 ppts	9 ppts	-2 ppts	15 ppts	16 ppts

Introducing myAir to patients

"After myAir was released, we actually sent an email to all our existing patients, informing them about this new feature"

Clinics, as well as home care providers, seem enthusiastic about myAir; and include information in the set-up instructions. As explained by a clinic in the UK:

"We explain about myAir as part of our general instruction. We don't demonstrate it specifically, but we give patients the brochure as part of the info pack"

"We also stress the fact that on myAir, the patients can see how they are doing – very important for those that have a need to demonstrate adherence in order to keep their jobs, like drivers or pilots. They can always know, they don't need to guess anymore"

One of the interviewed home care providers in Germany, however, went one step further in promoting myAir to their patients:

"After myAir was released, we actually sent an email to all our existing patients, informing them about this new feature.

All interviewed clinics and home care providers consistently introduce myAir to all patients, not only to the young people with smartphones. They say that most people, also the older, mostly have and use smartphones, and if they don't, there is often someone in their close family that can help them.

All interviewees expect significantly better behaviour from engaged patients, and they believe in the potential of myAir.

There are some examples of myAir patients being treated in a more efficient way by the clinics – here an example from the UK:

"For privacy and integrity reasons, we don't know if a patient has signed up for myAir or not – it doesn't show in our systems, However, when I do talk to a patients calling for help and they tell me they use myAir, I can sometimes point them to a video or instruction on myAir to help them faster than otherwise."

The clinics and home care providers we talk to say that myAir is very well received when they present it to their patients. They also receive positive feedback from patients having used myAir, and finding it motivating to "compete against themselves".

Although not possible to confirm in this study, several clinics and home care providers told us that they get the impression that patients use myAir intensively in the first month. This result goes well along with patients needing more support at the beginning of the treatment until they reach a stable level of adherence and get used to the therapy.

What do we expect from a "motivated" patient compared to others?
As this paper investigates patient engagement in general, as well as myAir in particular, we've talked to several clinics and home care providers about their general view on patient engagement. All clinics and home care providers tell us the same thing: engagement makes all the difference.

"I would expect an engaged patient to sleep perhaps an hour, hour and a half more every night"

We also spoke to a clinic in Finland – a clinic that has used telemonitoring for a long time, but only just recently started using myAir. Although it is still too new to have any statistically significant data, they say patients seem quite interested in the new tool:

"So far, almost all patients have expressed strong interest in this. For us, we hope it will enable more patients to manage themselves a little bit on their own"

Analysis and Conclusions

Intro

We have conducted a study of approximately over 23,000 patients on CPAP or APAP treatment for Obstructive Sleep Apnea (OSA). The patients are treated by different clinics and home care providers in the UK, Ireland and in Germany, and they are all monitored via telemonitoring by their nurse or physician.

Around approximately 1,800 of these patients have also registered to use myAir – a website enabling patients to follow their own treatment, and get automated feedback about their therapy. The patient also gets a "score" indicating how well they follow the prescribed treatment.

This paper has investigated if, and how, the myAir users differ from other patients, by testing the hypothesis "Patients that are engaged in their own treatment show significantly and measureable better adherence and usage than other patients".

Results

The study can confirm the hypothesis to be true: myAir patients show consistently better device usage and adherence than the control group.

myAir patients show better daily usage than other patients in this study

Usage

myAir patients show measurably better daily usage than other patients. The myAir patient group has higher average use and lower variation than the control group. This is true for all studied clinics and home care providers in both countries, and for new as well as established patients.

	Established patients		New patients	
Country	not myAir	myAir	not myAir	myAir
Germany Average usage:	5h 18min	6h 7min	5h 2min	5h54min
UK Average usage:	4h 5min	5h 22min	4h 41min	5h 40min

These numbers are well in line with Kuna et al who studied the effect of providing web acccess to patients treatment data:

Kuna et al. study: Usage first week	Average usage	Std deviation
Web-access	6h18m	+/- 2h30m
Web-access + financial incentive	5h54m	+/- 2h30m
Usual care	4h42m	+/- 3h18m

These numbers are similar to those found by Crocker et al, with average daily use of 5h54m for myAir patients and 4h54m for other patients (patients in the USA).

Germany Usage first week	Average usage	Std deviation
myAir	5h55m	+/- 2h44m
Not myAir	5h2m	+/- 3h7m

UK Usage first week	Average usage	Std deviation
myAir	5h27m	+/- 3h5m
Not myAir	4h43m	+/- 3h14m

In this study, as in other studies where patients are provided access to their own usage data via patient engagement tools such as myAir; patient device usage is well over 5 hours per night, regardless of whether they are new or established patients, in the UK, US or Germany.

Adherence
myAir patients have higher adherence than other patients. Again, true for both countries and all clinics and home care providers. Below is a summary table with all new patients in all clinics during the studied period.

Differences are seen in the very first days of treatment, and remain over time.

myAir patients have higher adherence than other patients

Weekly average adherence (minimum 4hours of daily use)
Both countries, new patients, Calibrated to day 1, first 8 weeks

Adherence % of patients	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
myAir	76%	81%	79%	78%	79%	78%	79%	81%
Not myAir	71%	70%	68%	67%	67%	66%	67%	68%
Difference	5 ppts	11 ppts	11 ppts	11 ppts	12 ppts	12 ppts	12 ppts	13 ppts

"myAir gives the patient a lot of information and insights about his sleep condition and what the perfect situation should be so they know what to work on, this is really valuable!"

myAir promotion and experiences from clinics and home care providers
The effort by the clinic or home care provider in introducing myAir to its clients has a strong impact on take-up.

All clinics and home care providers introducing myAir to their patients do so as part of the regular briefing instructions on how to set-up and use the device. One of the clinics also, regularly, ask the patient about myAir set-up when the patients calls in to the clinic for help. Overall, all clinics and home care providers feel that myAir patients need less traditional support than other patients.

Anecdotally, there are some examples of myAir patients being treated in a more efficient way by the clinics:

- One clinic has started to use the myAir website as an instruction tool, when helping patients over the phone. They guide the patient onto the website, and point them to videos or other resources to help the patient in a more efficient way than trying to explain for instance mask adjustment over the phone

Methodology

Hypothesis

Our hypothesis is defined as follows:

"Patients that use myAir show significantly and measurably better adherence and usage than other patients"

Method – hard data

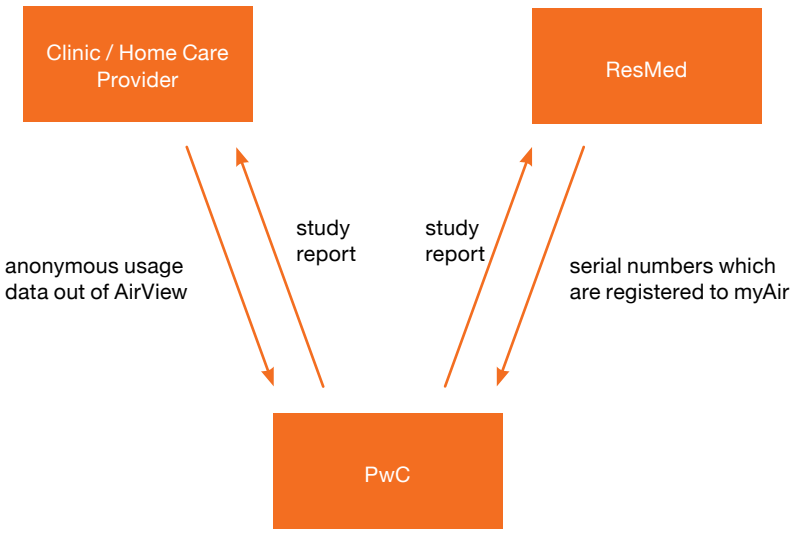
Access to data

In order to test whether patients that use myAir show significantly and measurably better adherence and usage than other patients, PwC has conducted a comparative study using data for two groups of patients: those that have, and those that have not, registered for myAir.

We have received the cooperation of several clinics and home care providers in the UK, Ireland and Germany, and they have provided us with anonymous daily usage data for all of their patients currently connected to ResMed AirView – i.e all patients in this study receive the benefits of telemonitoring.

In addition, we have received a list of serial numbers used to register a myAir account, and by combining these two sources we are able to create two separate groups of patients: those that have, and those that have not, registered for myAir.

Below is a summary graphic on the data flows



Use of data

The data provided to us regarding patients' daily device use covers historical data of usage. The different clinics and home care providers have given us somewhat varying time periods to analyse. However, for the period of 6 Feb 2016 until 28 April 2016, we have usage data for all patients. This is the time period we will use for the analyses.

What the data looks like

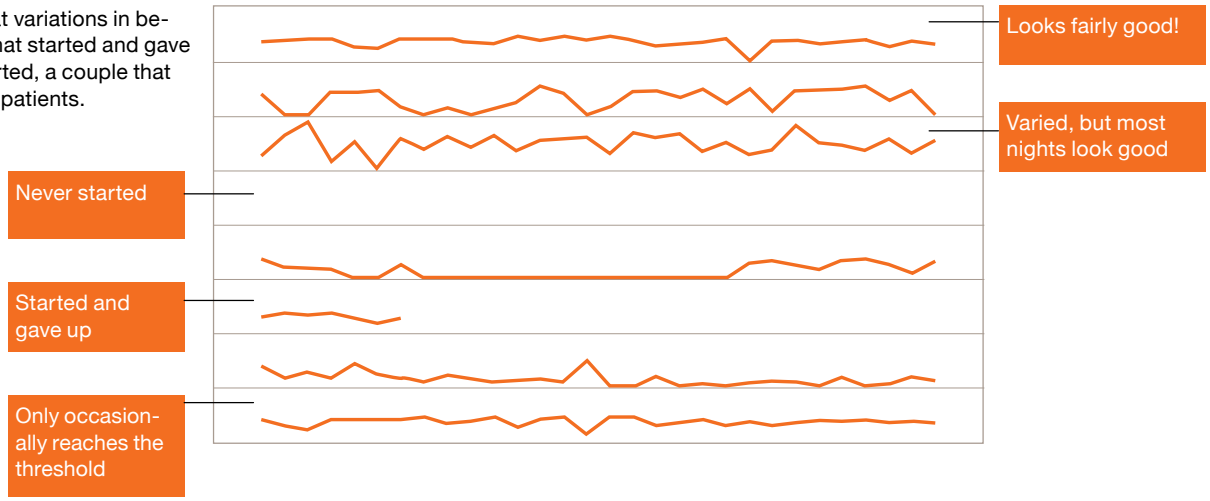
The picture below shows usage data for a random selection of patients, in their first month since the therapy started. All the patient data we have received is in this form. The data shows individual daily usage for anonymous patients.

In the study, we group the patients together and look at averages rather than at individuals.

Examples of first month daily usage

Germany, new patients, data calibrated from day 1

These examples show great variations in behaviour. We see a patient that started and gave up, a patient that never started, a couple that struggle, and a few "good" patients.



All the analyses will be performed comparing patient groups who have registered for myAir against patient groups who have not registered for myAir.

"Adherence" is defined as at least 4 hours of CPAP usage in a single night which is the reference for most German insurance companies to keep paying for treatment. The same definition is used for the UK.

Missing data is excluded. If we instead assume missing data means "zero usage on that day", all averages are lower, but the statistical significance between the "myAir"- group and the other patients remain ($P<0{,}0001$).

Difference in average device usage depending on treatment of missing data

Both countries, new patients, 6 February to 28 April 2016

Country / patient group	Average daily use missing data excluded	Average daily use missing data = 0
myAir patients	5 h 47 m	4 h 57 m
Other patients	4 h 55 m	3 h 37 m
Difference	52 minutes	40 minutes

Creating sub groups for analysis

The data from the clinics and home care providers also include the patient's setup date, which corresponds to the patients first day on CPAP treatment. Using this info, we have broken the data into two additional sub-groups: Established patients and New patients.

- New patients are all patients that started treatment on or after 6 February, 2015 (this is the earliest date for which we have data from all clinics).
- Established patients are all patients that started treatment on or before 20 December, 2015.
- When comparing the new and established patent groups, all patients with a setup date between 20 December, 2015 and 6 February, 2016, will be excluded, to ensure that the established group will have had time to become just that.

We will also do analyses on the full patient group, regardless of whether they are new or established.

Size of patient groups used in this analysis

Country / patient group	Established (set up before 20 Dec)	New (set up on or after 6 Feb)	All patients, i.e also including patients set-up between 21 Dec and 5 Feb
UK	1,537 (myAir 221)	569 (myAir 119)	2,434 (myAir 392)
Germany	15,245 (myAir 1,080)	4,627 (myAir 251)	21,391 (myAir 1,425)
Analyses to perform	• Adherence (% of patients that are adherent on any given day) • Average usage (average daily use for any given day)	• Adherence (% of patients that are adherent on any given day) • Average usage (average daily use for any given day) • 1st week, 1st month behaviour (usage, adherence)	• Adherence (% of patients that are adherent on any given day) • Average usage (average daily use for any given day)

Calibration of "day 1"
In order to analyse the new patients, we have calibrated the data set so that setup date=day1 in the analysis that looks specifically at new patients. For all other analyses, we use actual dates, i.e. when comparing daily usage between new and established patients, we use actual dates, but when we look at first week adherence in new patients, we use calibrated data.

Method – Interviews and previous studies

In addition to receiving data, we have interviewed several clinics and home care providers – the ones that have provided data, but also others that were unwilling to share data or did not have a sufficient number of myAir patient records for statistical analysis, but were interested in discussing the implications of patient empowerment.

We talked to the clinics and home care providers on the importance of patient engagement in general, and how the clinics perceive and use myAir specifically.

The interviews were semi-structured; all clinics and home care providers were asked to discuss three areas specifically:

1. If and how they promote myAir to their patients
2. What (if any) behavioural differences they have seen so far in myAir patients
3. What difference in adherence to prescribed treatment they would normally expect from an "engaged" patient compared to other patients.

The results from the interviews are interspersed in the paper as quotes and commentary on the data.

Previous studies
In addition to interviewing clinics and home care providers, we have read and referenced a number of other studies on patient engagement and adjacent subjects.

Limitations
There are two main limitations to this study.

- Firstly, we do not know anything about the patients except the country in which they are treated, the activation date, and their daily device usage over a two month period. We do not have access to their age, sex, AHI index or any other factors which might possibly be alternative explanations for the difference in behaviour between myAir patients and other patients.
- Patients registering for myAir might already be more engaged in their CPAP therapy than others not registering.
- The selection of patients includes only patients who are monitored through AirView, ResMed's online tool for the telemonitoring of patients. This means we only study patients using recent and modern CPAP devices, and that are either new patients, or that have recently been provided a new device. Furthermore we do not compare the telemonitored, engaged patients to the classical care pathways without telemonitoring

Appendix

About this research
This report is built on knowledge gathered first hand at a number of sleep clinics and home care providers across eight countries in Europe. These studies have been sponsored by ResMed, a global leading provider of positive airway pressure devices.

About PwC
PwC helps organisations and individuals create the value they´re looking for. We´re a network of firms in 157 countries with more than 200,000 people who are committed to delivering quality in assurance, tax and advisory services. Tell us what matters to you and find out more by visiting us at *www.pwc.com*. PwC refers to the PwC network and/or one or more of its member firms, each of which is a separate legal entity. Please see *www.pwc.com/structure* for further details.

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