Journal Pre-proof

National Implementation of CPAP Telemonitoring and a Pay-For-Performance Scheme for Homecare Providers in France Leads to Prioritisation of Resources to Individuals with Low Therapy Adherence: The IMPACT-PAP Cohort Study

Joëlle Texereau Sébastien Bailly Jean-Christian Borel Abdelkebir Sabil Jean Louis Pépin, on behalf of IMPACT-PAP contributors

Please cite this article as: Texereau J, Bailly S, Borel J-Christian, Sabil A, Pépin JL, National Implementation of CPAP Telemonitoring and a Pay-For-Performance Scheme for Homecare Providers in France Leads to Prioritisation of Resources to Individuals with Low Therapy Adherence: The IMPACT-PAP Cohort Study, *Archivos de Bronconeumología* (2024), doi: https://doi.org/10.1016/j.arbres.2024.06.008

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ORIGINAL ARTICLE

National Implementation of CPAP Telemonitoring and a Pay-For-Performance Scheme for Homecare Providers in France Leads to Prioritisation of Resources to Individuals with Low Therapy Adherence: The IMPACT-PAP Cohort Study

Joëlle Texereau[1,2§], Sébastien Bailly[3§], Jean-Christian Borel[3,4], Abdelkebir Sabil[5], Jean Louis Pépin[3]*, on behalf of IMPACT-PAP contributors[#]

[1]Air Liquide Healthcare, Bagneux

[2]Hôpital Cochin, AP-HP, Paris

[3]Université Grenoble-Alpes, CHUGA et INSERM U1300, Grenoble, France

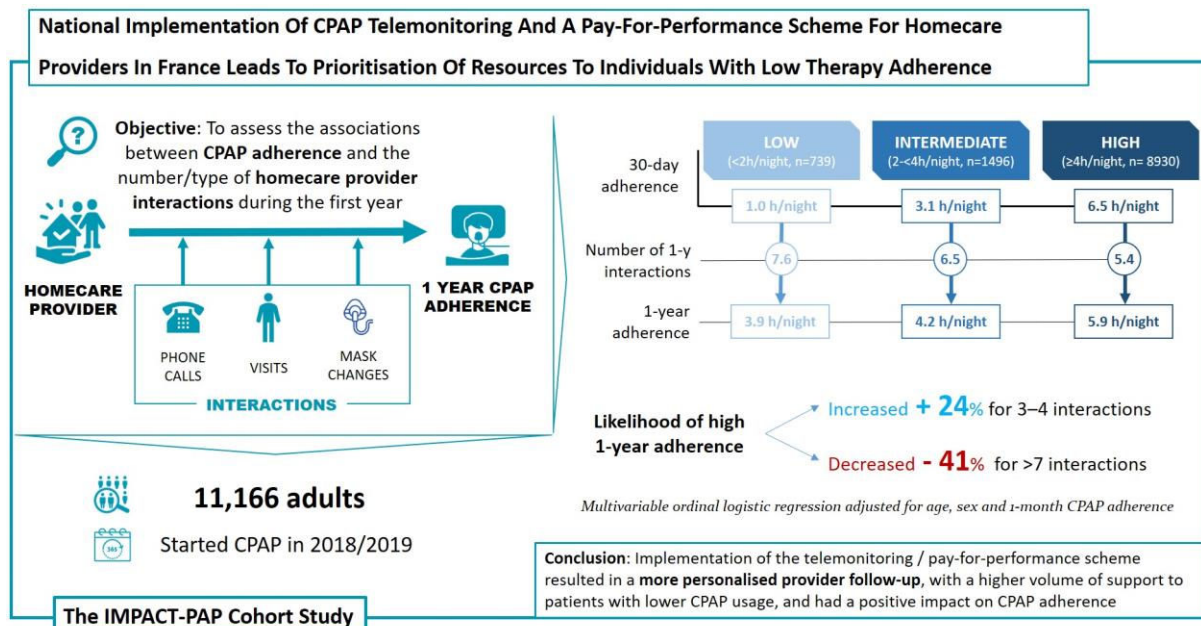[4]Département Recherche et Développement, AGIR à dom, Meylan, France

[5]Cloud Sleep Lab, Paris, France

*Corresponding author: Jean-Louis Pépin, Laboratoire EFCR, CHU de Grenoble, CS10217, 38043 Grenoble Cedex 9, France. Email: JPepin@chu-grenoble.fr

[§]Joint first authors

[#]Full details in the online supplement

Graphical abstract

Abstract

Introduction: Long-term adherence to continuous positive airway pressure (CPAP) therapy

for obstructive sleep apnoea remains suboptimal and low adherence increases healthcare

costs. This study investigated relationships between CPAP adherence and the intensity of

support provided by homecare providers after implementation of telemonitoring and pay-

for-performance reimbursement for CPAP in France.

Methods: Adults who started CPAP in 2018/2019, used telemonitoring, and had ≥1 year of

homecare provider data were eligible. The main objective was to determine associations

between CPAP adherence at 1 month (low [<2 h/night], intermediate [2 to <4 h/night], high

[≥4 h/night]) and the number/type of homecare provider interactions (home visits, phone

calls, mask change) during the first year.

Results: 11,166 individuals were included (mean age 59.8±12.7 years, 67% male). The number of homecare provider interactions per person increased significantly as 1-month CPAP usage decreased (7.65±4.3, 6.5±4.0, 5.4±3.4 in low, intermediate and high adherence groups; p<0.01). There was marked improvement in device usage over the first 5–6 months of therapy in the low and intermediate adherence subgroups (p<0.05 after adjustment for age, sex, initial CPAP adherence, and number of interactions). After adjustment for age, sex and 1-month adherence, having 3–4 interactions was significantly associated with better 1-year adherence (odds ratio 1.24, 95% confidence interval 1.05–1.46), while having >7 interactions was significantly associated with worse 1-year adherence.

Conclusions: The telemonitoring/reimbursement scheme in France had a positive impact on CPAP adherence and facilitated a more personalised approach to therapy management, focusing resources on patients with low and intermediate adherence.

Keywords: adherence, continuous positive airway pressure, healthcare resource use, homecare provider, obstructive sleep apnoea, telemonitoring

Introduction

Obstructive sleep apnoea (OSA) is a common condition in which the upper airway collapses intermittently during sleep, resulting in obstructive apnoeas and hypopnoeas that are associated with arousals from sleep and sympathetic activation.[1] It has been estimated that more than 900 million adults aged 30–69 years have OSA.[2] This number, along with the societal burden of OSA, appears to be increasing.[3] In France, an estimated 10 million individuals have OSA,[4] and the proportion of these individuals being treated with continuous positive airway pressure therapy (CPAP) has increased over the last decade.[5]

CPAP is the gold standard therapy for OSA. However, poor adherence to CPAP and high rates of therapy termination for a variety of reasons remain a significant challenge to the clinical effectiveness of this treatment modality.[6-9] This is because there is a dose-response effect regarding the effects of CPAP therapy on symptoms and incident comorbidities, and a growing body of evidence showing that there is an association between usage of/adherence to positive airway pressure (PAP) therapy and healthcare resource use and costs.[8,10-27]

In France, a new national CPAP telemonitoring and pay-for-performance scheme was implemented in 2018 (**Figure 1, Table S1**). This includes incentives to encourage the use of telemonitoring and a higher weekly fee paid to homecare providers if nightly CPAP usage hours increase (calculated based on 28-day moving windows). The system is applied continuously for the duration of CPAP therapy. In 2023, about 97% of CPAP-treated patient in France were being telemonitored. The weekly homecare package fees cover the CPAP device, mask and other consumables, mandatory home visits for device/interface set-up and adjustment, patient education, confirmation of tolerability, adherence monitoring, call centres, and support to improve adherence. Three visits during the first 4 months of CPAP therapy are mandatory, with annual visits thereafter for patients using telemonitoring. Homecare providers also need to provide a call centre service 24 hours a day, 7 days a week, a telemonitoring platform, and human resources to check telemonitoring data and inform the physician if adherence is poor. Homecare providers can deliver additional visits/calls to improve adherence but this does not result in payment of a higher weekly fee.

Our hypothesis was that the system change that occurred in France in 2018 and the associated introduction of telemonitoring and a pay-for-performance reimbursement model for CPAP-treated patients would have an impact on how homecare providers performed patient follow-up, including additional actions directed to improve adherence in OSA

patients who had poor initial CPAP device usage. Therefore, the IMPACT-PAP study

investigated relationships between CPAP adherence during the first year of therapy in

patients with OSA and the intensity of support provided by homecare providers in France.

Materials and methods

Study design and participants

This study included adults (age ≥18 years) who were started on CPAP (regular CPAP or

automatically titrating CPAP [APAP]) from January 2018 to December 2019, consented to the

remote daily telemonitoring of their CPAP data, had at least 1 year of homecare provider

data after CPAP therapy initiation, had at least 8 days of CPAP telemonitoring data, and had

their CPAP therapy managed by home healthcare provider companies that were affiliated to

either of two professional representative unions: Fédération Des Prestataires de Santé à

Domicile (FEDEPSAD) or Union des Prestataires de SAnté à Domicile Indépendants (UPSADI).

The study was performed in accordance with French regulations, and followed the

methodology MR-004 of the French Data Protection Authority ("Commission Nationale

Informatique et Liberté" CNIL) concerning research that reuses data that have already been

collected. Potential participants were provided with written information about the study and

were given the opportunity to decline the reuse of their personal data. The study was

registered on the national Health Data Hub Website (N°I52121510192019) and did not

require IRB approval.

Data collection

This study analysed prospectively collected data that were gathered by homecare

providers as part of routine practice. This included patient demographical data at the start of

CPAP therapy (age, sex and body mass index [BMI; body weight in kg/(height in metres)^2]), the date that CPAP therapy was started, objective daily CPAP usage (by date) transmitted from the CPAP device, and the number, date and type of interactions with the homecare provider (phone calls to patients, home visits, change in interfaces).

Participants were divided into subgroups based on the level of therapy adherence (and reimbursement) at 1 month after therapy initiation (low [<2 h/night], intermediate [2 to <4 h/night], and high [≥4 h/night]). The telemonitoring scheme was continued in all patients, irrespective of the level of adherence at 1 month. CPAP could only be discontinued at the request of the patient or by a decision by the treating physician.

Objectives

The main objective was to determine the number/type of homecare provider interactions during the first year of treatment based on the level of CPAP adherence at 1 month after therapy initiation. Secondary objectives were to describe the changes trajectories of adherence to CPAP in the first year after therapy initiation, and to determine factors associated with an improvement in the level of therapy adherence during the first year.

Statistical analysis

Data are presented as number and percentage for qualitative variables, and mean ± standard deviation for quantitative variables. For the primary endpoint, comparison between the three CPAP adherence groups (low, intermediate and high) were performed using the Chi-squared test for qualitative variables and the Kruskal-Wallis test for quantitative variables. Correction for multiple tests were performed using Bonferroni

correction. Univariable and multivariable ordinal logistic regressions were performed to

determine factors associated with 1-year CPAP adherence (adjusted for age, sex, BMI, type

of homecare provider-patient interaction [all, phone calls, visits, mask change], and

adherence level group at 1 month after therapy initiation). Changes in CPAP adherence

group over time during the first year after therapy initiation were described using a repeated

measure analysis of variance (ANOVA). A linear mixed model with a random effect on

patient was used to assess trajectories of CPAP adherence over time, considering

interactions between patient and homecare provider and key confounders (patient age and

sex, and initial adherence to CPAP therapy). All statistical analyses were performed with SAS

software, version 9.4. A p-value of ≤0.05 was defined as statistically significant.

Results

Study population

A total of 11,166 patients with OSA started on CPAP were included (mean age 59.8±12.7

years, 67% male) (**Table 1**), representing approximately 6% of the estimated patient

population starting CPAP over the study period (see online supplement for details). The

majority of patients (78%) had high adherence to CPAP at 1 month after therapy initiation

(**Table 1**). Mean device usage at 1 month was 5.7±2.1 h/night overall, 1.0±0.6 h/night in low

adherers (n=739), 3.1±0.6 h/night in intermediate adherers (n=1496), and 6.5±4.0 h/night in

high adherers (n=8930).

Relationships between the number of patient-provider interactions and CPAP adherence

during the first year of treatment (primary endpoint)

The mean number of home visits per person in the first year was 3.0±1.9, consistent with the relevant regulations (**Table 2**). The cumulative number of homecare provider interactions (overall, and by type) over the first year of treatment is shown in **Figure S1**. The proportion of individuals who received a greater number of home visits in the first year (3–4 and ≥5) was significantly higher in participants with low CPAP usage over the first month of therapy; this was also the case for all other types of homecare provider interactions (i.e. phone calls and mask changes) (**Table 2**).

After adjustment for age, sex and adherence at 1 month, having 3–4 total interactions was significantly associated with better 1-year adherence (odds ratio [OR] 1.24, 95% confidence interval [CI] 1.05–1.46) (**Figure 2, Table S2**). Having >7 total interactions was significantly associated with worse 1-year adherence (OR 0.59, 95% CI 0.50–0.70) (**Figure 2, Table S2**). Of the different types of interactions, home visits (up to 3) and mask changes (at least one) were significantly associated with better 1-year adherence (**Figure 2, Table S2**). Having any number of phone calls was significantly associated with worse 1-year adherence (**Figure 2, Table S2**).

Changes and trajectories of CPAP adherence in the first year

Mean device usage at 1 year was 5.5±2.2 h/night overall, 3.9±2.4 h/night in those with low adherence at 1 month, 4.2±2.2 h/night in those with intermediate adherence at 1 month, and 5.9±2.0 h/night in those with high adherence at 1 month. There was initial marked improvement in device usage over the first 6 months of therapy in the subgroups with low or intermediate adherence at 1 month after therapy initiation (**Figure 3**). The increase in CPAP adherence over the first 6 months of therapy was statistically significant in a multivariable mixed model considering time in months and adjusted for age, sex, initial

CPAP adherence, and number of homecare provider-patient interactions (p<0.05); changes in CPAP adherence from 6–12 months were not statistically significant.

Changes in adherence group (low, intermediate or high device usage) mainly occurred during the first 5 months of therapy (**Figure 4**). Eighty-four percent of patients who had high adherence to CPAP therapy at 1 month maintained that level of usage at 1 year, 56.9% who had intermediate adherence at 1 month had high adherence at 1 year, and 49.5% who had low adherence at 1 month had high adherence at 1 year.

Factors associated with improved CPAP adherence group

Patients who improved their CPAP device usage during the first year of therapy were significantly younger and had significantly more interactions with the homecare provider (overall and by type) compared with individuals who had consistently high adherence (**Table S3**). The number of homecare provider interactions varied based on the change in CPAP adherence group over time. For example, in the subgroup with low adherence at 1 month, the mean number of phone calls per person was higher in those who still had low adherence at 1 year (2.98) than in those who had improved to having high adherence at 1 year (2.27), and was highest in the group with intermediate adherence at 1 month and low adherence at 12 months (3.32) (**Figure S2**).

Discussion

In this cohort of CPAP-treated patients with OSA from France, the widespread national implementation of a telemonitoring and a pay-for-performance scheme for homecare providers had an important impact on the number of interactions targeting patient adherence during the first year after CPAP initiation. Patients with low or intermediate CPAP

usage (<4 h/night) in the first month after therapy initiation received a higher volume and different type of support than adherent patients. Homecare provider interactions for patients with low early adherence occurred primarily during the first five months after therapy initiation. In addition, there was a ceiling effect in terms of the number of interactions, whereby an increase above four interactions per patient was not associated with any further improvement in adherence, suggesting that interactions after that point become unhelpful, and potentially a waste of resources.

The increasing number of patients diagnosed with OSA and managed with CPAP therapy places a significant burden on finite healthcare resources. Therefore, new approaches to the management of CPAP therapy that strike a balance between remote monitoring utilising digital technologies and in-person patient-healthcare professional contacts are needed, as suggested by a study conducted in Finland.[3] However, to date, little attention has been paid to the assessment of new management pathways, including pay-for-performance models, in terms of their effect on patient care and adherence to CPAP therapy. Our study is novel in highlighting the impact of the national deployment of a novel strategy for the management of CPAP therapy, and in showing that financial performance incentives encourage homecare providers to target resources and interactions to individuals who have the lowest CPAP adherence in the first month of therapy.

Our finding that >4 interactions per person were not associated with any incremental CPAP device usage benefit suggests that the reasons underlying persistent poor adherence are probably not related to technical aspects that can be addressed by homecare provider interactions. Instead persistent poor adherence might be explained by other factors such as health behaviours, attitudes and beliefs, the presence of insomnia or other comorbidities that result in disturbed sleep, and/or socioeconomic factors.[6,28] The identification of these

factors is essential to allow the application of different strategies to target these specific issues with the goal of improving CPAP device usage and therapy benefit.

This study also determined the relative impact of different types of homecare interactions (phone call, home visit, mask change). Mask resupply has already been shown to be associated with improved long-term adherence to CPAP therapy.[29,30] In this analysis, our data suggested that face-to-face visits were more effective than phone calls at improving CPAP device usage. In contrast, it has previously been shown that telemonitoring with automated feedback messaging was sufficient to improve 90-day adherence to CPAP therapy in an unselected population.[31]

Consistent with existing evidence,[32-34] our data showed that when CPAP adherence is achieved early, it is generally maintained over time (between 1 month and 1 year based on our data). Homecare provider interactions are generally concentrated in the first 5 months after CPAP therapy initiation and reduce thereafter. Our findings support this approach, because more than four interactions within the first year of therapy was not associated with any incremental benefit on CPAP device usage at 1 year.

Overall, our study clearly shows that regular reassessment of device usage (adherence) by telemonitoring combined with a pay-for-performance strategy means that homecare provider actions are targeted to individuals with lower CPAP adherence, which was associated with overall improved adherence and a greater number of patients achieving adherence of >4 h/night. Telemonitoring is a key component of this approach, and enables or triggers the appropriate educational or supportive actions by the homecare provider.[35,36] Another important message from our analysis is that the current French model, which includes three compulsory visits in the first 4 months after CPAP therapy initiation, does not consider the diversity of patients and OSA phenotypes. Therefore, the current system could

potentially be revised to allow avoidance of home visits for individuals with good early adherence that is stable over time. This may contribute to more efficient allocation of healthcare resources. A better approach might be to allow homecare providers to operate using a patient-centred model, with varying levels and types of support based on each individual's profile, within the current pay-for-performance-based strategy.

Strengths of this study include the representativeness of the study population, which covers approximately 6% of the total number of incident individuals starting CPAP in France in 2018–2019. In addition, the data were obtained from a range of different providers, non-profit organisations and private companies, who may have had different processes for patient management. There are also some limitations that need to be considered when interpreting our results. Firstly, we did not have any data on sleep duration, OSA severity (symptoms, AHI at diagnosis), comorbidities or socioeconomic factors to allow us to adjust for the impact of these potential confounders on adherence.[13,37] Secondly, although we had information about the number and type of homecare provider interactions, we did not have details about the specific reason for each interaction. Finally, this study included patients who had a full year of follow-up data after CPAP therapy initiation and are therefore only applicable to similar individuals who have persisted with CPAP therapy and accept interactions with their homecare provider. The findings also relate to the current CPAP management policies and protocols in France and therefore may not be directly applicable to different healthcare settings and practices.

In conclusion, this study shows for the first time that a CPAP telemonitoring and pay-for-performance scheme for homecare providers can have a positive impact on adherence to CPAP therapy and redirects interactions to those with low early adherence. This facilitates a

more personalised approach to CPAP therapy management, and has the potential to contribute to improved outcomes.

Author contributions

JLP, SB and JT prepared the outline for the first draft manuscript. The first draft of the manuscript was prepared by JLP, SB and JT with the assistance of an independent medical writer (Nicola Ryan) funded by FEDEPSAD. The manuscript was reviewed and edited by all the authors. All authors approved the final version of the manuscript and made the decision to submit the manuscript for publication.

Role of sponsor

Representatives of the study sponsor were involved in the design of the study. Data from the different homecare companies involved in the study were collated by an independent clinical research organisation (Alira Health), which also performed data cleaning and

homogenisation. The first draft of the manuscript was prepared by JLP, SB and JT with the assistance of an independent medical writer funded by FEDEPSAD. The manuscript was reviewed and edited by all the authors. All authors made the decision to submit the manuscript for publication and assume responsibility for the accuracy and completeness of the analyses and for the fidelity of this report to the trial protocol.

References

1. Lévy P, Kohler M, McNicholas WT, Barbé F, McEvoy RD, Somers VK, et al. Obstructive sleep apnoea syndrome. Nat Rev Dis Primers. 2015;**1**:15015. doi:10.1038/nrdp.2015.15

2. Benjafield AV, Ayas NT, Eastwood PR, Heinzer R, Ip MSM, Morrell MJ, et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. Lancet Respir Med. 2019;**7**:687-698. doi:10.1016/s2213-2600(19)30198-5

3. Mattila T, Hasala H, Kreivi HR, Avellan-Hietanen H, Bachour A, Herse F, et al. Changes in the societal burden caused by sleep apnoea in Finland from 1996 to 2018: A national registry study. Lancet Reg Health Eur. 2022;**16**:100338. doi:10.1016/j.lanepe.2022.100338

4. Balagny P, Vidal-Petiot E, Renuy A, Matta J, Frija-Masson J, Steg PG, et al. Prevalence, treatment and determinants of obstructive sleep apnoea and its symptoms in a population-based French cohort. ERJ Open Res. 2023;**9**10.1183/23120541.00053-2023

5. Mandereau-Bruno L, Léger D, Delmas MC. Obstructive sleep apnea: a sharp increase in the prevalence of patients treated with nasal CPAP over the last decade in France. PLoS One. 2021;**16**:e0245392. doi:10.1371/journal.pone.0245392

6. Mendelson M, Duval J, Bettega F, Tamisier R, Baillieul S, Bailly S, Pépin JL. The individual and societal prices of non-adherence to continuous positive airway pressure, contributors, and strategies for improvement. Expert Rev Respir Med. 2023;**17**:305-317. doi:10.1080/17476348.2023.2202853

7. Rotty MC, Suehs CM, Mallet JP, Martinez C, Borel JC, Rabec C, et al. Mask side-effects in long-term CPAP-patients impact adherence and sleepiness: the InterfaceVent real-life study. Respir Res. 2021;**22**:17. doi:10.1186/s12931-021-01618-x

8. Pépin JL, Bailly S, Rinder P, Adler D, Szeftel D, Malhotra A, et al. CPAP therapy termination rates by OSA phenotype: a French nationwide database analysis. J Clin Med. 2021;**10**10.3390/jcm10050936

9. Rotenberg BW, Murariu D, Pang KP. Trends in CPAP adherence over twenty years of data collection: a flattened curve. J Otolaryngol Head Neck Surg. 2016;**54**:43. doi:

10. Bakker JP, Weaver TE, Parthasarathy S, Aloia MS. Adherence to CPAP: what should we be aiming for, and how can we get there? Chest. 2019;**155**:1272-1287. doi:10.1016/j.chest.2019.01.012

11. Bock JM, Needham KA, Gregory DA, Ekono MM, Wickwire EM, Somers VK, Lerman A. Continuous positive airway pressure adherence and treatment cost in patients with obstructive sleep apnea and cardiovascular disease. Mayo Clin Proc Innov Qual Outcomes. 2022;**6**:166-175. doi:10.1016/j.mayocpiqo.2022.01.002

12. Chhatre S, Chang YHA, Gooneratne NS, Kuna S, Strollo P, Jayadevappa R. Association between adherence to continuous positive airway pressure treatment and cost among medicare enrollees. Sleep. 2020;**43**10.1093/sleep/zsz188

13. Cistulli PA, Armitstead JP, Malhotra A, Yan Y, Vuong V, Sterling KL, et al. Relationship between self-reported sleepiness and positive airway pressure treatment adherence in obstructive sleep ppnea. Ann Am Thorac Soc. 2023;**20**:1201-1209. doi:10.1513/AnnalsATS.202206-482OC

14. Cistulli PA, Malhotra A, Cole KV, Malik AS, Pépin JL, Sert Kuniyoshi FH, et al. Positive airway pressure therapy adherence and health care resource use in patients with obstructive sleep apnea and heart failure with preserved ejection fraction. J Am Heart Assoc. 2023;**12**:e028733. doi:10.1161/jaha.122.028733
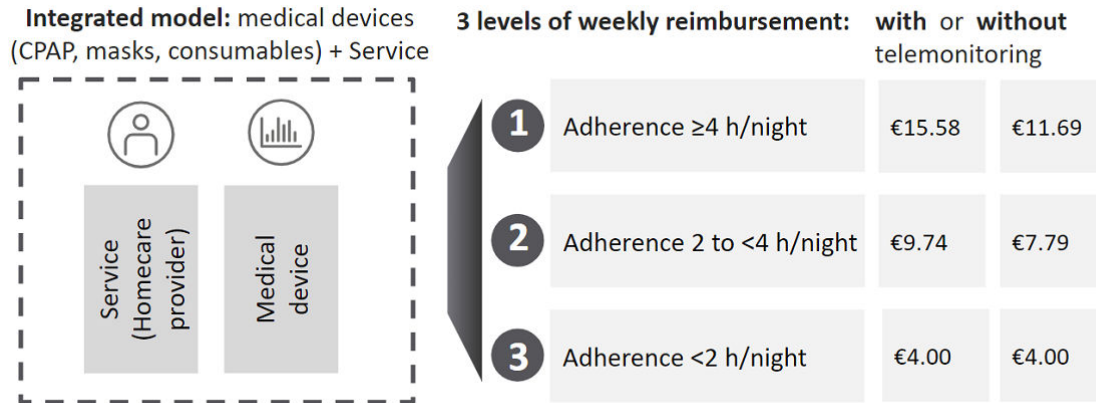
15. Gervès-Pinquié C, Bailly S, Goupil F, Pigeanne T, Launois S, Leclair-Visonneau L, et al. Positive airway pressure adherence, mortality, and cardiovascular events in patients with sleep apnea. Am J Respir Crit Care Med. 2022;**206**:1393-1404. doi:10.1164/rccm.202202-0366OC

16. Malhotra A, Cole KV, Malik AS, Pépin JL, Sert Kuniyoshi FH, Cistulli PA, et al. Positive airway pressure adherence and health care resource utilization in patients with obstructive sleep apnea and heart failure with reduced ejection fraction. J Am Heart Assoc. 2023;**12**:e028732. doi:10.1161/jaha.122.028732

17. Malhotra A, Sterling KL, Cistulli PA, Pépin JL, Chen J, Woodford C, et al. Dose-response relationship between obstructive sleep apnea therapy adherence and healthcare utilization. Ann Am Thorac Soc. 2023;**20**:891-897. doi:10.1513/AnnalsATS.202208-738OC

18. Patil SP, Ayappa IA, Caples SM, Kimoff RJ, Patel SR, Harrod CG. Treatment of adult obstructive sleep apnea with positive airway pressure: an American Academy of Sleep Medicine systematic review, meta-analysis, and GRADE assessment. J Clin Sleep Med. 2019;**15**:301-334. doi:10.5664/jcsm.7638

19. Pépin JL, Tamisier R, Benjafield AV, Rinder P, Lavergne F, Josseran A, et al. CPAP resumption after a first termination and impact on all-cause mortality in France. Eur Respir J. 2024;**63**10.1183/13993003.01171-2023

20. Sánchez-de-la-Torre M, Gracia-Lavedan E, Benitez ID, Sánchez-de-la-Torre A, Moncusí-Moix A, Torres G, et al. Adherence to CPAP treatment and the risk of recurrent cardiovascular events: a meta-analysis. JAMA. 2023;**330**:1255-1265. doi:10.1001/jama.2023.17465

21. Sterling KL, Alpert N, Cistulli PA, Pépin JL, More S, Cole KV, Malhotra A. Healthcare resource utilisation and costs in patients with treated obstructive sleep apnea. J Sleep Res. 2023:e14099. doi:10.1111/jsr.14099

22. Sterling KL, Alpert N, Malik AS, Pépin JL, Benjafield AV, Malhotra A, et al. Association between sleep apnea treatment and health care resource use in patients with atrial fibrillation. J Am Heart Assoc. 2024;**13**:e030679. doi:10.1161/jaha.123.030679

23. Sterling KL, Cistulli PA, Linde-Zwirble W, Malik A, Benjafield AV, Malhotra A, et al. Association between positive airway pressure therapy adherence and health care resource utilization in patients with obstructive sleep apnea and type 2 diabetes in the United States. J Clin Sleep Med. 2023;**19**:563-571. doi:10.5664/jcsm.10388

24. Sterling KL, Pépin JL, Linde-Zwirble W, Chen J, Benjafield AV, Cistulli PA, et al. Impact of positive airway pressure therapy adherence on outcomes in patients with obstructive sleep apnea and chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2022;**206**:197-205. doi:10.1164/rccm.202109-2035OC

25. Wickwire EM, Bailey MD, Somers VK, Oldstone LM, Srivastava MC, Johnson AM, et al. CPAP adherence is associated with reduced inpatient utilization among older adult Medicare beneficiaries with pre-existing cardiovascular disease. J Clin Sleep Med. 2022;**18**:39-45. doi:10.5664/jcsm.9478

26. Wickwire EM, Cole KV, Dexter RB, Malhotra A, Cistulli PA, Sterling KL, Pépin JL. Depression and comorbid obstructive sleep apnea: Association between positive airway pressure adherence, occurrence of self-harm events, healthcare resource utilization, and costs. J Affect Disord. 2024;**349**:254-261. doi:10.1016/j.jad.2023.12.055

27. An J, Glick HA, Sawyer AM, Arguelles J, Bae CJ, Keenan BT, et al. Association Between Positive Airway Pressure Adherence and Health Care Costs Among Individuals With OSA. Chest. 2023;**163**:1543-1554. doi:10.1016/j.chest.2023.01.025

28. Shaukat R, Gamal Y, Ali A, Mohamed S. Adherence to Positive Airway Pressure Therapy in Patients With Obstructive Sleep Apnea. Cureus. 2022;**14**:e25946. doi:10.7759/cureus.25946

29. Benjafield AV, Oldstone LM, Willes LA, Kelly C, Nunez CM, Malhotra A, On Behalf Of The medXcloud G. Positive airway pressure therapy adherence with mask resupply: a propensity-matched analysis. J Clin Med. 2021;**10**10.3390/jcm10040720

30. Scharf MT, Keenan BT, Pack AI, Kuna ST. Mask Refills as a Measure of PAP Adherence. J Clin Sleep Med. 2017;**13**:1337-1344. doi:10.5664/jcsm.6810

31. Hwang D, Chang JW, Benjafield AV, Crocker ME, Kelly C, Becker KA, et al. Effect of telemedicine education and telemonitoring on continuous positive airway pressure adherence. The Tele-OSA randomized trial. Am J Respir Crit Care Med. 2018;**197**:117-126. doi:10.1164/rccm.201703-0582OC

32. Qiao M, Xie Y, Wolff A, Kwon J. Long term adherence to continuous positive Airway pressure in mild obstructive sleep apnea. BMC Pulmonary Medicine. 2023;**23**:320. doi:10.1186/s12890-023-02612-3

33. Van Ryswyk E, Anderson CS, Antic NA, Barbe F, Bittencourt L, Freed R, et al. Predictors of long-term adherence to continuous positive airway pressure in patients with obstructive sleep apnea and cardiovascular disease. Sleep. 2019;**42**10.1093/sleep/zsz152

34. Chai-Coetzer CL, Luo YM, Antic NA, Zhang XL, Chen BY, He QY, et al. Predictors of long-term adherence to continuous positive airway pressure therapy in patients with

obstructive sleep apnea and cardiovascular disease in the SAVE study. Sleep.

2013;**36**:1929-37. doi:10.5665/sleep.3232

35. Askland K, Wright L, Wozniak DR, Emmanuel T, Caston J, Smith I. Educational, supportive

and behavioural interventions to improve usage of continuous positive airway pressure

machines in adults with obstructive sleep apnoea. Cochrane Database Syst Rev.

2020;**4**:Cd007736. doi:10.1002/14651858.CD007736.pub3

36. Hoet F, Libert W, Sanida C, Van den Broecke S, Bruyneel AV, Bruyneel M. Telemonitoring

in continuous positive airway pressure-treated patients improves delay to first

intervention and early compliance: a randomized trial. Sleep Med. 2017;**39**:77-83.

doi:10.1016/j.sleep.2017.08.016

37. May AM, Patel SR, Yamauchi M, Verma TK, Weaver TE, Chai-Coetzer CL, et al. Moving

toward Equitable Care for Sleep Apnea in the United States: Positive Airway Pressure

Adherence Thresholds: An Official American Thoracic Society Policy Statement. Am J

Respir Crit Care Med. 2023;**207**:244-254. doi:10.1164/rccm.202210-1846ST

Figure Legends

Integrated model: medical devices (CPAP, masks, consumables) + Service

Service (Homecare provider)

Medical device

3 levels of weekly reimbursement: **with** or **without** telemonitoring

|		with	without
1	Adherence ≥4 h/night	€15.58	€11.69
2	Adherence 2 to <4 h/night	€9.74	€7.79
3	Adherence <2 h/night	€4.00	€4.00

Mandatory home visits to be performed by the homecare provider:

- 3 visits during the first 4 months
- 1 visit per year for telemonitored patients
- 2 visits per year for non-telemonitored patients

Fig. 1. CPAP telemonitoring and pay-for-performance homecare provider scheme in France (2023 reimbursement amounts). CPAP, continuous positive airway pressure.
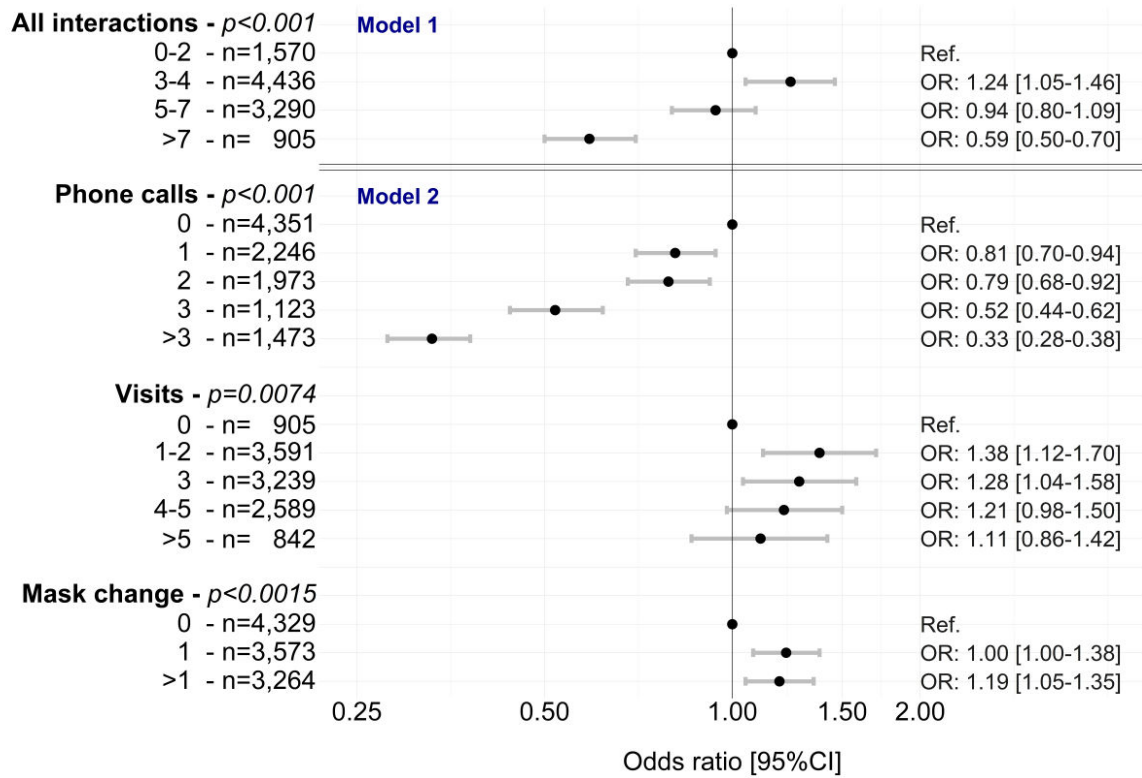
Fig. 2. Multivariable analyses (mixed ordinal regressions) of the association between homecare interactions (overall [model 1] and by type [model 2]) and changes in adherence to continuous positive airway pressure in the first year of therapy. All models were adjusted for age, sex and time, including a random effect on patient. CI, confidence interval; OR, odds ratio.
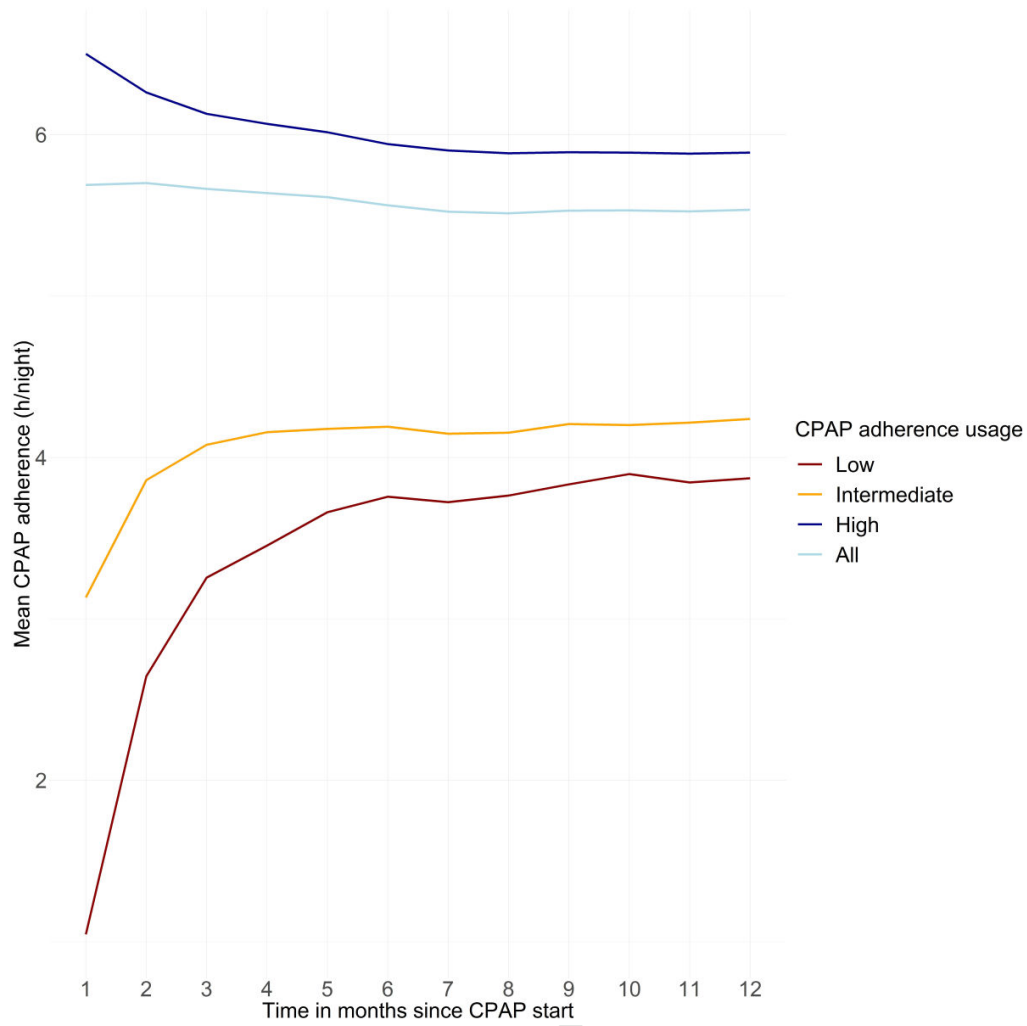
Fig. 3. Continuous positive airway pressure (CPAP) device usage over the first year of therapy, overall and by initial adherence group. Low, device usage <2 h/night; Intermediate, device usage 2 to <4 h/night; High, device usage ≥4 h/night.
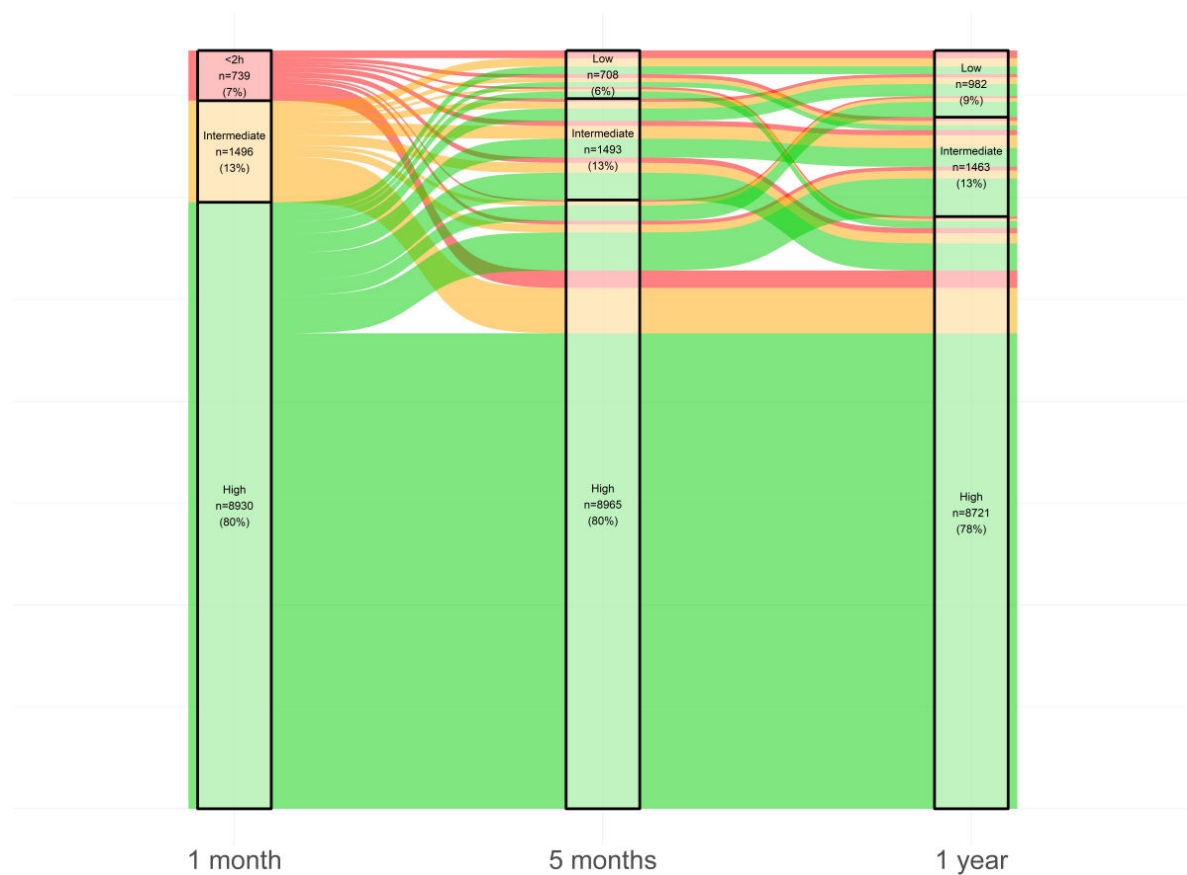
Fig. 4. Sankey plot showing the trajectories of continuous positive airway pressure device usage over the first year of therapy. At each timepoint, the number (%) of patients in each compliance class (<2h/n; [2-4[h/n; ≥4h/n) is indicated. The colours of the lines represent the 1-month adherence subgroup (low [<2 h/night] in red; intermediate [2 to <4 h/night] in orange; high [≥4 h/night] in green), and increasing line thickness indicates an increasing number of patients.

Tables

Table 1 Participant demographic and clinical characteristics at baseline, overall and by adherence group at 1 month after therapy initiation.

	Overall (n=11,166)	CPAP usage over the first month				Missing, n
		Low (n=739)	Intermediate (n=1496)	High (n=8930)	p-value[a]	
Age, years	59.8±12.7	58.9±13.3	57.6±13.2*	60.2±12.6*[#]	<0.01	0
Male sex, n (%)	7442 (66.7)	505 (68.3)	1,027 (68.6)	5,910 (66.2)	0.11	2
Body mass index, kg/m^2	32±7.1	31.9±7.3	31.8±7.2	32.0±7.0	0.19	1194

Values are mean ± standard deviation, or number of participants (%).

CPAP, continuous positive airway pressure monitoring.

[a]For pairwise between-group comparisons after correction for multiple tests.

*p<0.05 vs. low adherence group after correction for multiple testing.

[#]p<0.05 vs. intermediate adherence group after correction for multiple testing.

Table 2 Homecare provider interactions during the first year of continuous positive airway pressure therapy in the overall population and in subgroups based on adherence group at 1 month after therapy initiation.

	Overall (n=11,166)	CPAP usage over the first month			
		Low (n=739)	Intermediate (n=1496)	High (n=8930)	p-value
Home visits	3.0±1.9	3.6±2.2	3.3±2.0	2.9±1.8	<0.01

Number of patients with, n (%):					
1–2 visits per person	4,496 (40.3)	214 (29.0)	537 (35.9)*	3,744 (41.9)*#	<0.01
3–4 visits per person	5,014 (44.9)	350 (47.4)	658 (44)*	4,006 (44.9)*#	
≥5 visits per person	1,656 (14.8)	175 (23.7)	301 (20.1)*	1,180 (13.2)*#	
Phone calls	1.5±1.7	2.5±2.1	1.9±1.9	1.4±1.6	<0.01
Number of patients with, n (%):					
0 phone calls per person	4,351 (39.0)	176 (23.8)	470 (31.4) *	3,704 (41.5)*#	<0.01
1 phone calls per person	2,246 (20.1)	106 (14.3)	279 (18.6) *	1,861 (20.8)*#	
2 phone calls per person	1,973 (17.7)	123 (16.6)	245 (16.4) *	1,605 (18.0)*#	
3 phone calls per person	1,123 (10.1)	109 (14.7)	190 (12.7) *	824 (9.2)*#	
>3 phone calls per person	1,473 (13.2)	225 (30.4)	312 (20.9) *	936 (10.5)*#	
Mask changes	1.1±1.2	1.3±1.2	1.1±1.2	1.1±1.1	<0.01
Number of patients with, n (%):					

0 mask changes per person	4,329 (38.8)	245 (33.2)	574 (38.4)*	3,509 (39.3)*	<0.01
1 mask change per person	3,573 (32.0)	203 (27.5)	455 (30.4)*	2,915 (32.6)*	
≥2 mask changes per person	3,264 (29.2)	291 (39.4)	467 (31.2)*	2,506 (28.1)*	.
Total interactions	5.7 ±3.6	7.65±4.3	6.5±4.0	5.4±3.4	<0.01
Number of patients with, n (%):					
0–2 interactions per person	1,570 (14.1)	64 (8.7)	179 (12.0)*	1,326 (14.8)*#	<0.01
3–4 interactions per person	4,436 (39.7)	86 (11.6)	296 (19.8)*	2,488 (27.9)*#	
5–7 interactions per person	3,290 (29.5)	254 (34.4)	509 (34.0)*	3,288 (36.8)*#	
>7 interactions per person	905 (8.1)	335 (45.3)	512 (34.2)*	1,828 (20.5)*#	

Values are mean ± standard deviation, or number of patients (%).

*p<0.05 vs. low adherence group after correction for multiple testing.

#p<0.05 vs. intermediate adherence group after correction for multiple testing.