Effectiveness of e-health interventions on improving adherence to treatment for patients with obstructive sleep apnea: A Meta-analytic review

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English summary

Introduction: Poor adherence to treatment of patients with obstructive sleep apnea (OSA) is a worldwide issue. E-health is a promising mean to address the relatively poor adherence to therapy. The aim of the current meta-analytic review was to investigate the effectiveness of a broad range of e-health interventions on improving adherence to continuous positive airway pressure (CPAP) or mandibular repositioning device (MRD) treatment for patients with obstructive sleep apnea (OSA).

Method: A systematic literature search was conducted in the databases of Cochrane library, PsychINFO, PubMed, and Embase, in order to identify relevant randomized controlled trials conducted in adult OSA populations. The risk of bias of included studies was examined with seven items of the Cochrane Collaboration's Risk of Bias tool.

Results: Nineteen studies were identified. All studies focused on the effects of adherence to CPAP, and no studies were identified for MRD. The methodological quality of the studies varied considerably. The meta-analysis included 18 studies, comprising 5429 patients, with post-intervention data varying from one to six months after baseline depending on the length of the experimental intervention. The results demonstrated that e-health interventions as add-on or replacement of care as usual, increased the average nightly CPAP use in hours as compared to care as usual (*MD* = 0.54, *95% CI* = 0.29 to 0.79). High statistical heterogeneity was found (I^2 = 90%). The results of the first subgroup analysis comparing studies investigating e-health as add-on to CAU (*n* = 13) (*MD* = 0.54, *95% CI* = 0.20 to 0.87) to e-health as replacement of CAU (*n* = 5) (*MD* = 0.52, *95% CI* = 0.13 to 0.91), demonstrated no significant differences between these type of studies (*p* = .95). A second subgroup analysis was carried out within the sample of add-on studies, herein distinguishing between experimental interventions including only telephone support (*n* = 7 studies with 3867 patients) (*MD* = 0.73, *95% CI* = 0.72 to 1.20), versus interventions comprising both telemonitoring and e-support (*n* = 4 studies with 504 patients) (*MD* = 0.39, *95% CI* = -0.46 to 1.23), versus interventions comprising self-monitoring without additional (e-) support from a healthcare provider (*n* = 2 studies with 245 patients) (*MD* = 0.31, *95% CI* = -1.19 to 1.82). The results did not reveal a significant difference in the effect on CPAP adherence (*p* = .71).

Conclusion: The results of this meta-analysis demonstrate that the provision of e-health interventions during follow-up care of CPAP treatment for patients with OSA seems to increase adherence to CPAP treatment in the first months after starting CPAP treatment, with a mean estimate of approximately half an hour. Findings need to be interpreted with caution, given the varying methodological quality of the included studies, the high heterogeneity of the main findings, as well as the fact that the included type and intensity of both care as usual and experimental interventions varied considerably. The specific type, timing, duration and intensity of (an) e-health intervention(s) that healthcare providers could effectively implement, remains unclear.

Nederlandse samenvatting

Introductie: Lage of geringe therapietrouw van patiënten met obstructieve slaap apneu (OSA) is een wereldwijd probleem. Het doel van dit meta-analytische review was om de effectiviteit van e-health interventies te onderzoeken wat betreft het vergroten van therapietrouw bij patiënten met OSA die worden behandeld met een Mandibulair Repositie Apparaat (MRA) of een continuous positive airway pressure (CPAP) apparaat.

Methode: Een systematische zoektocht naar relevante literatuur werd uitgevoerd in de databases van Cochrane, PsychINFO, PubMed, en EmBase, waarbij werd gezocht naar gerandomiseerd gecontroleerde studies gericht op volwassen (≥ 18 jaar) patiënten met OSA. Kwaliteitsbeoordeling van geïncludeerde studies vond plaats aan de hand van zeven items van de zogenaamde Cochrane Collaboration's Risk of Bias tool.

Resultaten OSA: Er werden 19 studies geïdentificeerd die het effect van e-health interventies op therapietrouw aan CPAP onderzochten. Er werden geen studies gevonden die het effect op therapietrouw aan MRA onderzochten. De methodologische kwaliteit van de studies varieerde aanzienlijk. De meta-analyse werd uitgevoerd over 18 studies (*N* = 5429 patiënten) met beschikbare post-interventie data, waarbij de interventieperiode varieerde van één tot 6 maanden. De resultaten lieten zien dat e-health interventies als toevoeging op, of vervanging van, gebruikelijke zorg, het gemiddeld aantal uren CPAP-gebruik per nacht deed verhogen (*MD* = 0.54, *95% CI* = 0.29 tot 0.79). De statistische heterogeniteit was hoog (I^2 = 90%). In een eerste subgroepanalyse werden de effecten op CPAP therapietrouw van studies die e-health interventies als toevoeging op gebruikelijke zorg onderzochten (*n* = 13) (*MD* = 0.54, *95% CI* = 0.20 to 0.87) vergeleken met studies die e-health als vervanging van gebruikelijke zorg onderzochten (*n* = 5) (*MD* = 0.52, *95% CI* = 0.13 to 0.91). De resultaten lieten geen significante verschil tussen de subgroepen zien (*p* = .95). Een tweede subgroep analyse werd uitgevoerd binnen de studies die e-health interventies als toevoeging op gebruikelijke zorg onderzochten. Hierbij werd onderscheid gemaakt tussen experimentele interventies die telefonische ondersteuning van een zorgprofessional bevatte (*n* = 7 studies met 3867 patiënten) (*MD* = 0.73, *95% CI* = 0.72 to 1.20), interventies die zowel telemonitoring als een vorm van e-support van een zorgprofessional bevatte (*n* = 4 studies met 504 patiënten) (*MD* = 0.39, *95% CI* = -0.46 to 1.23), en interventies die e-zelf-monitoring bevatte zonder additionele ondersteuning van een zorgprofessional (*n* = 2 studies met 245 patiënten) (*MD* = 0.31, *95% CI* = -1.19 to 1.82). De resultaten lieten geen significant verschil zien op de mate van therapietrouw (*p* = .71).

Conclusie: De resultaten van deze meta-analyse laten zien dat e-health interventies als toevoeging op, of vervanging van, gebruikelijke zorg, de CPAP therapietrouw naar schatting met een gemiddelde van ruim een half uur kunnen verhogen in de eerste maanden na het starten van deze behandeling. Er is

voorzichtigheid geboden bij het interpreteren van de resultaten, gezien de variaties in methodologische kwaliteit van de geïncludeerde studies, de hoge statistische heterogeniteit in de gevonden resultaten, en het feit dat zowel de controle als experimentele interventies veel variatie lieten zien wat betreft inhoud en intensiteit. Het specifieke type e-health interventie dat ingezet zou kunnen worden om therapietrouw te bevorderen, evenals de timing, de duur, en intensiteit, blijft daarmee onduidelijk.

1. Project introduction

In 2013, the Dutch National Healthcare Institute started a program focusing on providing appropriate healthcare (‘*Zinnige zorg’*). All available Dutch healthcare interventions that are offered as part of the Dutch basic healthcare insurance package, are systematically screened. The aim of the program is to identify and remove inefficient an unnecessary care, in order to enhance the quality of care, improve health, and reduce unnecessary costs. As part of this program, the Dutch National Healthcare Institute aims to examine the role of e-health in improving patient adherence to treatments for lung diseases asthma, chronic obstructive pulmonary disease (COPD), and obstructive sleep apnea (OSA).

This report focuses specifically on the latter target population: patients with OSA. More specifically, the aim of the current study was to investigate the effectiveness of a broad range of e-health interventions on improving adherence to continuous positive airway pressure (CPAP) or mandibular repositioning device (MRD) treatment for patients with OSA, by means of a systematic review and meta-analysis.

2. Methods

2.1 Search strategy

The search strategy for the three lung diseases was pooled into one search. To identify relevant studies, a systematic literature search was conducted in the electronic databases of Cochrane library (Wiley), PsychINFO (EBSCO), PubMed, and Embase from January 1, 2000 to March 20, 2018. Numerous terms related to 1) e-health technology, 2) patient adherence, and 3) the target population (i.e. OSA, asthma, COPD) were combined using both free-text and index terms (for full search string, see Appendix 1). In addition, reference lists of the included studies as well as systematic reviews on the research topic were checked for potential relevant additional studies.

2.2 PICO and study selection

The following PICO was established:

P	Participants	Patients with diagnosed OSA who underwent CPAP treatment or treatment with a MRD. Diagnosis was supported by a polysomnography, home sleep apnea testing, or nocturnal pulse oximetry.
I	Intervention	An e-health intervention (see study inclusion criteria 2 for more details) aimed to improve patient adherence to treatment with CPAP or MRD.
C	Comparison	A study condition in which participants received usual (follow-up) care (CAU) regarding CPAP or MRD, without the experimental e-health intervention under investigation.
O	Outcome	Any reported outcome measure related to patient adherence or persistence with CPAP or MRD treatment.

Study inclusion criteria were (*please note that the PICO criteria correspond to inclusion criteria one to four respectively):*

1) Target population: patients with diagnosed OSA who underwent CPAP treatment or treatment with a MRD. Diagnosis was supported by a polysomnography, home sleep apnea testing, or nocturnal pulse oximetry.

2) (One of) The primary/main component(s) or the majority of the experimental intervention was delivered by means of e-health technology, or, the e-health component was investigated as an add-on to CAU, independent of whether this comprised a minor or major part of the intervention being studied. The criteria for being an e-health intervention was met when:
    - the intervention was delivered by means of Information and communications technology (ICT), such as telephone calls, telemedicine (e.g. videoconferencing), websites, smartphone applications, short text messages (SMS).
    - the intervention was delivered independent of time and place, hence distance being a critical factor (i.e. videos delivered in a face-to-face session are not considered an E-health intervention).
3) Intervention effects were compared to CAU regarding CPAP or MRD, without the experimental e-health intervention under investigation.
4) Study investigated the effects of an e-health intervention on at least one quantitative measure of patient adherence to CPAP or MRD.
5) Adherence measure(s) were statistically compared between study groups
6) Target age study populations: ≥ 18 years
7) Study design was a randomized controlled trial
8) Availability of full-text article in English or Dutch language
9) Publication date between January 2000 and March 18, 2018

A study exclusion criteria, related to inclusion criteria 3, was the control condition being an active or placebo control condition including the same e-health component as the experimental intervention. For example, this would be the case when only the content of the interventions would be different, such as general versus tailored SMS.

Initially, two reviewers (J.A. and L.L.) independently screened all titles and abstracts for eligibility criteria. Disagreements were resolved by discussion. Subsequently, the two reviewers independently screened the full-text articles of the selected papers in order to determine eligibility for the current review, and extracted individual study data accordingly for eligible studies. Covidence (Covidence systematic review software) was used to manage the screening process and risk of bias assessment.

2.4 Data extraction

Two reviewers (J.A. and L.L.) extracted the following data of all eligible studies:

- Study reference:
    - Authors
    - Year of publication
    - Country in which study was conducted
- Study design characteristics:
    - Study conditions and sample size (*N*)
    - Measurements
- Study population:
    - Age (*M, SD*)
    - Gender (% female)
    - Target population and recruitment strategy
    - Eligibility criteria
    - Diagnostic procedure / OSA definition
- Interventions:
    - E-health condition
        - Add-on or replacement of CAU
        - Type of technology
        - Type of intervention
        - Duration and frequency of intervention component
    - Control condition
- Outcome(s):
    - Assessment of adherence
    - Operationalization of adherence
- Results:
    - Effects (*M,* SD) on adherence, including tests for significance (*p*-values)
- Other:
    - Source of funding and competing interest
    - Study limitations and other comments

2.5 Data analyses and syntheses

A meta-analytic review was conducted to investigate the effectiveness of a broad range of e-health interventions on improving adherence to treatment (CPAP or MRD) for patients with OSA. Software Comprehensive Meta-Analysis (CMA, version 3.3.070) was used to conduct the analyses and for computing differences in means (*MD*) in adherence measures, i.e. the average number of nightly hours using the CPAP machine or MRD device. The data for the meta-analysis comprised post-intervention, whereby intervention periods varied from one to six months.

In case a study included multiple intervention conditions, the control condition was split into two or more groups corresponding to the number of experimental comparisons, and the sample sizes were divided by this number accordingly. This allowed for comparisons of intervention conditions separately within the same meta-analysis.

Given that considerable heterogeneity was to be expected amongst studies, a random-effects model was chosen. This model assumes that the studies represent a random sample of effect sizes that could have been observed (Borenstein M., Hedges L. V., Higgins J. P. T., & Rothstein H. R, 2009). Heterogeneity between the observed effect sizes of studies was examined with the I^2 statistic. Values of 0% indicate no observed heterogeneity, whereas values of 25%, 50%, and 75% indicate low, moderate, and high heterogeneity respectively. We used the non-central $\chi 2$-based approach within the HETEROGI module for Stata (Orsini, Bottai, Higgins, & Buchan, 2006) to calculate 95% confidence intervals around I^2.

Funnel plots were visually inspected in order to assess potential publication bias. Furthermore, the trim-and-fill procedure of Duval and Tweedie (2000) was conducted to account for any potential publication bias. This procedure produces an adjusted estimate of the effect size by accounting for missing studies by means of imputation. Additionally, funnel plot symmetry was checked with Egger's linear regression test of the intercept (Egger, Davey Smith, Schneider, & Minder, 1997).

Statistical outliers were defined as studies of which the 95% CI of the MD did not overlap with the 95% CI of the pooled MD. In case outliers were identified, sensitivity analyses were conducted by removing these studies from the analysis in order to examine the degree to which exclusion would affect the results.

Two subgroup analyses were conducted according to the mixed-effects model, pooling the studies within subgroups with the random-effects model, whereas testing for significant differences between subgroups with the fixed-effects model. One subgroup analyses compared studies that tested the e-health interventions as add-on to CAU, to studies that tested these interventions as

replacement of CAU. This is interesting as the context in which the e-health intervention is provided could have serious consequences for the implementation of the intervention within the (follow-up) care process, as well the efficiency and burden on the healthcare system. The other subgroup analyses was conducted because of the explicit interest of ZIN in the effect of telemonitoring on top of usual care, hence conducted within the sample of add-on studies thereby distinguishing between experimental interventions including only telephone support versus interventions comprising e-support as well as telemonitoring versus self-monitoring without additional (e-) support from a healthcare provider.

If included studies did not report the necessary data to conduct main- or subgroup-analyses in a meta-analysis, we attempted to contact the first or corresponding author to gain the necessary data (Bouloukaki et al., 2014; Lo Bue et al., 2014; Stepnowsky, Edwards, Zamora, & Barker, 2013; Taylor, Eliasson, Andrada, Kristo, & Howard, 2006).

2.6 Quality assessment

The Cochrane Collaboration's Risk of Bias tool (Higgins & Green, 2011) was used to assess the quality of all included studies. Two reviewers (J.A. and L.L.) independently evaluated the following dimensions of risk of bias: 1) adequacy of random sequence generation, 2) adequacy of concealment of allocation sequence to personnel, 3) blinding of study participants and personnel, 4) blinding of outcome assessors, 5) adequacy of handling of incomplete outcome data, 6) selective outcome reporting, and 7) potential other sources of bias. Regarding criteria 6, low risk of bias was scored for studies for which the study protocol was available and all pre-specified outcomes were reported, or when the protocol was not available but the standard outcome assessment of CPAP adherence, reflecting average nightly CPAP use, was reported. Each study was rated on each dimension as "low risk", "high risk", or "unclear risk". Disagreements were resolved by discussion.

3. Results

3.1 Search and screening

Figure 1 presents the PRISMA flowchart, which describes the process of literature screening and selection. The literature search was conducted as part of the broader project (see 'project introduction'), hence simultaneously searching for studies with target populations being patient with asthma or COPD. The systematic search for the literature regarding the three lung diseases resulted in 3049 potentially relevant articles after duplicates had been removed (*n* = 723). After title and abstract screening, a total of 123 studies were selected for further full-text screening to check for eligibility in the current systematic review. Of these, 56 studies targeted OSA, 43 targeted asthma, and 24 targeted COPD. Assessment of the eligibility criteria as well as the results of the corresponding included studies are summarized in the following sections regarding OSA only. Full-text eligibility screening of 56 studies led to the exclusion of 37 studies (for more details, see Appendix 2). A total of 19 studies targeting individuals with OSA were included in this review.

3.2 Meta-analytic review

3.2.1 Study characteristics

Appendix 3 provides an overview of the relevant characteristics of each of the included studies. All the studies focused on individuals with OSA starting Continuous Positive Airway Pressure (CPAP) or Automatically-Adjusting Positive Airway Pressure (APAP) treatment. No studies were identified for patients with OSA being treated by MRD. The diagnoses of OSA were supported by data regarding AHI (*n* = 17), RDI (*n* = 1), and oxygen desaturation index (ODI) (*n* = 1) stemming from polysomnography's, home sleep apnea testing, or nocturnal pulse oximetry's. Fifteen studies used solely sleep quality to support a diagnosis, whereas four studies additionally required clinical symptoms in terms of sleepiness (Hui et al., 2000). In 16 studies, the investigation of the intervention on treatment adherence was (one of) the primary aim(s) of the study. In the remaining 3 studies, the primary focus was on comparing functional outcomes (Fields et al., 2016), assessing the delay to identifying technical problems with CPAP treatment (Hoet et al., 2017), and investigating the effect on blood pressure reduction (Mendelson et al., 2014) respectively. Adherence to CPAP was most often assessed by the average nightly CPAP use in hours (with and without the criteria '*on nights being used'*), the percentage of nights using CPAP (with and without the criteria *'for more than X hours a night'*), and the percentage of patients being adherent to CPAP.

Most of the studies (*n* = 14) compared CAU, to CAU supplemented with one or more e-health components. For reasons of brevity, these studies will from here on be referred to as '*add-on studies'*. In the remaining five studies, the e-health component(s) were used to replace, instead of supplement, CAU. These studies will from here on be referred to as '*replacement studies'*.

Of the 14 '*add-on studies*' comparing CAU to the same care supplemented with e-health, nine studies added solely E-health components, whereas five studies added a combination of face-to-face and E-health strategies. The studies adding solely e-health components, most often comprised tele-monitoring tools (*n* = 7) for monitoring of CPAP adherence and efficacy data, and/or telephone calls (*n* = 7) with the aim to educate, provide support, stimulate self-management, or reinforce adherence to CPAP treatment. One of these studies (Hwang et al., 2018) also included a web-based education portal, as well as automated feedback messages (e-mail, telephone, or SMS) based on CPAP monitoring data. Furthermore, Mendelson et al. (2014) provided study participants a smartphone with an application incorporating a self-monitoring tool able to transmit clinical information, as well as self-care messages by means of daily provided pictograms. In the five studies that added a combination of face-to-face and e-health strategies, the e-health component generally comprised telephone calls for the purpose of troubleshooting, providing support and encouragement, and reinforce adherence to CPAP treatment. The face-to-face components mainly comprised face-to-face visits for the purpose of education, consultation, and/or early review (Bouloukaki et al., 2014; Hui et al., 2000; Nilius et al., 2012; Pengo et al., 2018), or comprised a brief motivational enhancement program (Lai, Fong, Lam, Weaver, & Ip, 2014).

With respect to the five 'replacement studies', face-to-face follow-up visits were replaced by e-health strategies. More specifically, Fields et al. (2016) replaced four face-to-face follow-up visits by one video-conferencing visit and three telephone calls. Three other studies replaced face-to-face visits by tele-monitoring units and subsequent collaborative management (Stepnowsky, Palau, Marler, & Gifford, 2007) or so-called 'as needed' clinical contacts (Stepnowsky et al., 2013; Taylor et al., 2006). That is, in case of mask leaks or low adherence. Finally, Isetta et al. (2015) replaced two face-to-face follow-up visits that were part of usual care, with follow-up care at distance. More specifically, two video-conferencing visits, extra tele-visits or telephone calls as-needed, and a web-based portal including education, self-monitoring, and a messaging tool to communicate with staff to solve CPAP treatment-related problems.

Most studies included post-intervention assessments between one and four months after baseline, except for the the study of Isetta et al. (2015), whom's intervention lasted for six months. Five studies included follow-up assessments after finishing the intervention (Bouloukaki et al., 2014; Lai et al., 2014; Lo Bue et al., 2014; Sedkaoui et al., 2015; Stepnowsky et al., 2013), ranging from 1

month (Lai et al., 2014) to 2 years (Bouloukaki et al., 2014). This variation was largely due to the different durations of the interventions, as for example the intervention of Lai et al. only comprised a motivational interview when starting CPAP, and a telephone call 2 days after.

As shown in Appendix 3, the type and intensity of CAU varied considerably. Often, participants received education about OSA and/or CPAP, treatment instructions, and one or more follow-up assessments by sleep specialized by means of telephone, home visits, or face-to-face visits to the clinic.

3.2.2 Quality assessment

Figure 2 presents the results of the risk of bias assessment separately for each individual study, whereas Figure 3 shows the averaged risk of bias across all included studies. The methodological quality of the studies varied. One study met low risk of bias for only two out of the seven criteria, eight met three criteria, four met four criteria, another four studies met five criteria, and two studies met six out of seven criteria.

Not a single study was rated as having low risk of bias on all seven assessment dimensions. This was largely due to ratings of high risk of bias on the "blinding of participants and personnel" dimension in all 19 studies. Such a high risk of bias rating is common for (at least partially) person-delivered interventions where blinding participants and personnel to whether they receive or provide a treatment is often not possible (Higgins & Green, 2011).

Regarding the randomization procedure, only about 53% (*n* = 10) of the studies seemed to have adequately generated a random sequence, whereas no information on the sequence generation was provided in the other studies. Furthermore, in the majority of studies (14 out of 19; 73.6%), it was unclear whether allocation of care was adequately concealed.

Most studies were scored as low risk of bias regarding blinding of outcome assessment, due to outcomes of CPAP adherence data being downloaded directly from CPAP devices. Except for one study (Isetta et al., 2015), which did not report on the assessment method of adherence or handling adherence data.

The risk of selective outcome reporting was considered low in 17 out of 19 (89.5%) studies, as these incorporated the standard criterion of CPAP usage reflecting average nightly use of CPAP. A high risk was identified for two studies that incompletely reported on outcomes in terms of different types of adherence outcomes as specified in the method sections of these papers (Bouloukaki et al., 2014; Hwang et al., 2018), and pre-defined outcome periods (Bouloukaki et al., 2014).

Eight out of 19 studies were rated as high risk of attrition bias (see Figure 2). For these studies, the handling of incomplete outcome data was considered likely to be biased, given that data was

generally not analyzed according to an intent-to-treat approach, hence excluding individuals who do did not adhere to the intervention, or who were lost to follow-up. Dropout rates in these 8 studies ranged from 10% (Hui et al., 2000; Nilius et al., 2012) to as high as 70% (Hwang et al., 2018).

The identified high risks of 'other sources of bias' (n = 4) were in two studies related to significant baseline differences which were not controlled for in the analyses (Fields et al., 2016; Hui et al., 2000). In another study (Kuna et al., 2015) it was reported that about 80% of participants receiving CAU, or CAU plus web-access to PAP data were treated with APAP instead of CPAP, whereas APAP was used in only 62% of participants in a third study arm (i.e. CAU + web-access to PAP data + financial incentive). The fourth study with high risk of another source of bias (Taylor et al., 2006) was due to similar availability of follow-up care in each study condition. More specifically, the increased number of telephonic contacts to the telemedicine group was balanced by walk-in care accessed by the traditional care group, which might have confounded the results.

3.2.3 Publication Bias

Egger's linear regression test of the intercept was significant (p < .05), but a visual inspection of the funnel plot and the trim-and-fill procedure did not indicate potential publication bias. When we conducted the latter procedure, no studies were removed and imputed.

3.2.3 Meta-analytic effects of e-health interventions on CPAP adherence

Of the nineteen identified studies, the study of Lo Bue et al. (2014) could not be included in the meta-analysis, as post-intervention data on the average nightly CPAP usage was missing and was only provided for the 1-year follow-up. Consequently, eighteen studies, including 22 comparisons between experimental and control conditions, were included in the meta-analysis as these provided post-treatment data on CPAP adherence in terms of average nightly usage in hours. The results are shown in Table 1 and Figure 4 (CMA plot). The use of e-health technology was associated with a significant, moderate improvement in patients' average nightly CPAP use in hours at post-intervention measurement (*MD* = 0.54, *95% CI* = 0.29 to 0.79), with high heterogeneity (I^2 = 90%). The exclusion of studies that were identified as outliers (Bouloukaki et al., 2014; Hoet et al., 2017; Hui et al., 2000; Hwang et al., 2018; Lai et al., 2014; Mendelson et al., 2014) resulted in a rounded similar mean difference (for more details, see Table 1), while leading to a considerable decrease in heterogeneity (I^2 = 51%).

3.2.4 Review of (follow-up) effects of e-health interventions on CPAP adherence

Given that the study of Lo Bue et al. (2014) could not be included in the meta-analysis on post-intervention data, we will narratively review the post-intervention results of this study in this section. Directly after the intervention period which lasted for a month, the monthly average number of night that the CPAP device was used for a minimum of 4 hours (see Appendix 3 'results' for more details), was significantly higher among participants receiving CAU plus extra early support and advice by means of telephone as compared to individuals receiving only CAU (p = .02). In addition, participants in the CAU plus extra early support and advice by telephone condition, showed a significant higher percentage of adherence when this was defined as using the CPAP device for ≥ 4 hours a night for at least 70% of the nights.

Regarding follow-up effects, only four studies conducted follow-up analyses. Given the limited number of studies conducting follow-up analyses, and the large variation in follow-up periods, no meta-analysis was conducted. Given the large variation in follow-up periods, we review the follow-up data by splitting the follow-up periods into short-term follow-up, being one to six months, and long-term follow-up, being one year or longer.

Three studies followed-up their patients in the short-term, namely at 3 months (Lai et al., 2014), 3 and 6 months (Lo Bue et al., 2014), and 4 months (Stepnowsky et al., 2013) respectively. Lo Bue et al. (2014) did not report in detail on 3- and 6-month follow-up data. The study of Lai et al. (2014) found that participants who received a brief motivational enhancement education program on top of CAU demonstrated at 3-month follow-up 1) a higher mean nightly CPAP use in hours, 2) a higher percentage of adherers (i.e. adherers defined as those using the CPAP device for ≥4 hours a night on at least 70% of nights, 3) a higher intention to use the CPAP device (i.e. % of nights on which CPAP had been switched on), and 4) a higher usage index (i.e. % of nights in which the CPAP device had been used for ≥4 hours). Finally, the results of Stepnowsky et al. (2013) showed that 4-month follow-up, the average nightly CPAP use in hours was higher for participants who received a telemonitoring intervention with a web-based portal for education and self-monitoring, as compared to participants received usual follow-up care existing of predetermined contacts with clinical staff (p = .03).

Regarding long-term follow-up, Bouloukaki et al. (2014) included a 2-year follow-up and Lo Bue et al. (2014) included a 1-year follow-up. Findings of the former study showed that at 2-year FU, telephone support in addition to CAU was superior to CAU in terms of a range of CPAP adherence outcomes measures, i.e. % and number of nights having used CPAP, average nightly CPAP use in hours on nights being used, and % of regular users as defined by average use of CPAP for ≥ 4 hours a night on ≥70% of nights (all p < .001) (Bouloukaki et al., 2014). However, findings of Lo Bue et al. (2014) demonstrated that at 1-year FU, telephone support in addition to CAU was not more effective than CAU in terms of increasing the nightly CPAP use in hours.

3.2.5 Subgroup analysis

The first subgroup analysis compared studies investigating e-health as add-on to CAU (*n* = 13) (Bouloukaki et al. 2014; DeMolles et al. 2004; Fox et al. 2006; Hoet et al. 2007; Hui et al. 2000; Hwang et al. 2018; Kuna et al. 2015; Lai et al. 2014; Mendelson et al. 2014; Nilius et al. 2012; Pengo et al. 2018; Sedkouaki et al. 2015; Turino et al. 2017) to e-health as replacement of CAU (*n* = 5) (Fields et al. 2016; Isetta et al. 2015; Stepnowsky et al. 2007; Stepnowsky et al. 2013; Taylor et al. 2006). The results of the mixed effects analysis demonstrated no significant difference in CPAP adherence between the above-mentioned type of studies (see Table 1).

Given the explicit interest of ZIN in the effect of telemonitoring on top of usual care, we also conducted a meta-analysis within the sample of add-on studies with available post-intervention data, herein distinguishing between experimental interventions including only telephone support (*n* = 7) (Bouloukaki et al., 2014; DeMolles, Sparrow, Gottlieb, & Friedman, 2004; Hui et al., 2000; Lai et al., 2014; Nilius et al., 2012; Pengo et al., 2018; Sedkaoui et al., 2015) versus interventions comprising e-support as well as telemonitoring (*n* = 4) (Fox et al., 2012; Hoet et al., 2017; Hwang et al., 2018; Turino et al., 2017) versus self-monitoring without additional (e-) support from a healthcare provider (*n* = 2) (Kuna et al., 2015; Mendelson et al., 2014) (for more details, see Appendix 3). Please note that the experimental interventions in the second subgroup only included telemonitoring based on objective data of CPAP machines, hence not including patients' self-reported adherence data. The results of this subgroup analysis can be found in Table 1. Although higher CPAP adherence was found for studies including experimental interventions by telephone only (*MD* = 0.73, *95% CI* = 0.27 to 1.20) as compared to studies including experimental interventions comprising either e-support plus telemonitoring (*MD* = 0.39, *95% CI* = -0.46 to 1.23) or self-monitoring (*MD* = 0.31, *95% CI* = -1.19 to 1.28) respectively, the results of the mixed effects analysis did not reveal a significant difference between these subgroups (see Table 1).

4. Conclusion

This meta-analysis investigated the impact of e-health interventions on improving adherence to CPAP or MRD treatment for patients with OSA. Nineteen eligible studies were identified focusing on CPAP adherence, whereas no studies were identified regarding adherence to MRD treatment. The meta-analysis including 18 studies and demonstrated a heterogeneous collection of e-health interventions as add-on or replacement of CAU to increase adherence to CPAP treatment compared to CAU alone with an average of approximately half an hour when measured during the intervention period. No significant differences were found between the effects of studies investigating e-health as add-on to CAU in comparison to studies investigating the effect of e-health as replacement of CAU. In addition, within the sample of add-on studies, no significant differences were found between experimental interventions including only telephone support, interventions comprising both telemonitoring and e-support, and interventions comprising self-monitoring without additional (e-) support from a healthcare provider. The findings need to be interpreted with caution, given the varying methodological quality of the included studies, the high heterogeneity of the results, as well as the fact that the included type and intensity of both care as usual and experimental interventions varied considerably. Within the group of studies investigating e-health intervention as add-on to CAU, no differences were found between the effects of e-health interventions comprising telephone support versus interventions comprising both telemonitoring and e-support versus .

Several limitations of this meta-analysis should be mentioned. First, follow-up data beyond post-treatment measurements could not be investigated due to the limited data available, hence the long-term effectiveness of e-health interventions focusing on increasing adherence to CPAP remains unknown. Another limitation is that moderate to high heterogeneity was observed, which may have biased the results. Also, the type and intensity of CAU as provided in the control conditions varied considerably and this may have influenced study results. Moreover, in several studies (as-needed) telephone support was part of CAU, whereas in other studies telephone support was part of the experimental intervention condition. Finally, the results are limited to populations scoring generally well above the threshold for severe OSA. It remains unclear whether the results would generalize to populations with less severe, that is, moderate OSA.

Providing e-health interventions during follow-up care of CPAP treatment for patients with OSA can slightly increase adherence to CPAP treatment in the first months after starting CPAP treatment. E-health technologies can be used as a tool to help deliver standardized education, as well as closely monitor patients in their daily life, thereby allowing for early detection of problems and non-adherence and subsequent timely and appropriate interventions at distance. The specific type of e-

health intervention that healthcare providers could implement, as well as its timing, duration and intensity, remain unclear.

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Figure 1: PRISMA flowchart describing study identification and selection process.

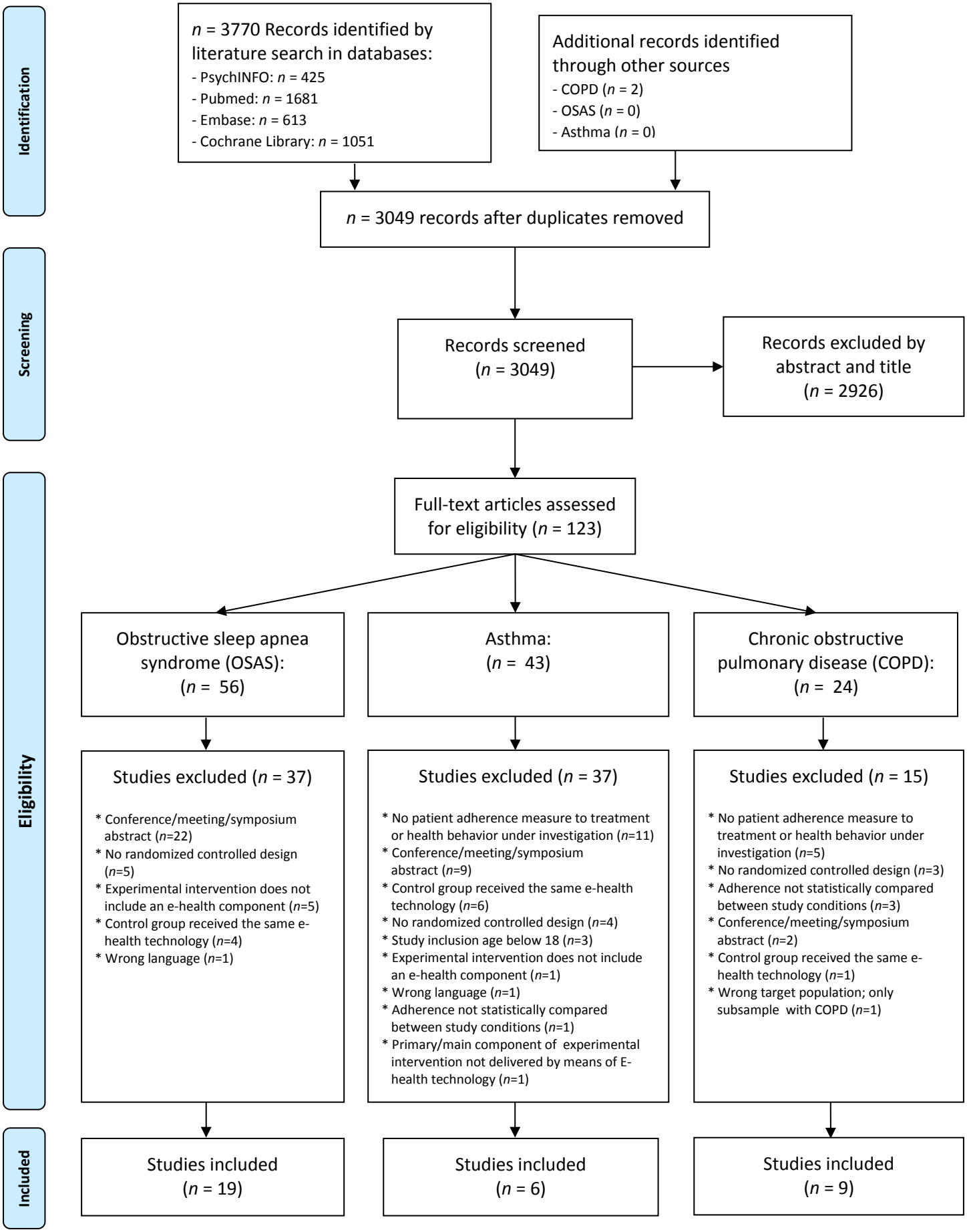


Figure 2: Risk of bias for each individual study included in this meta-analysis.

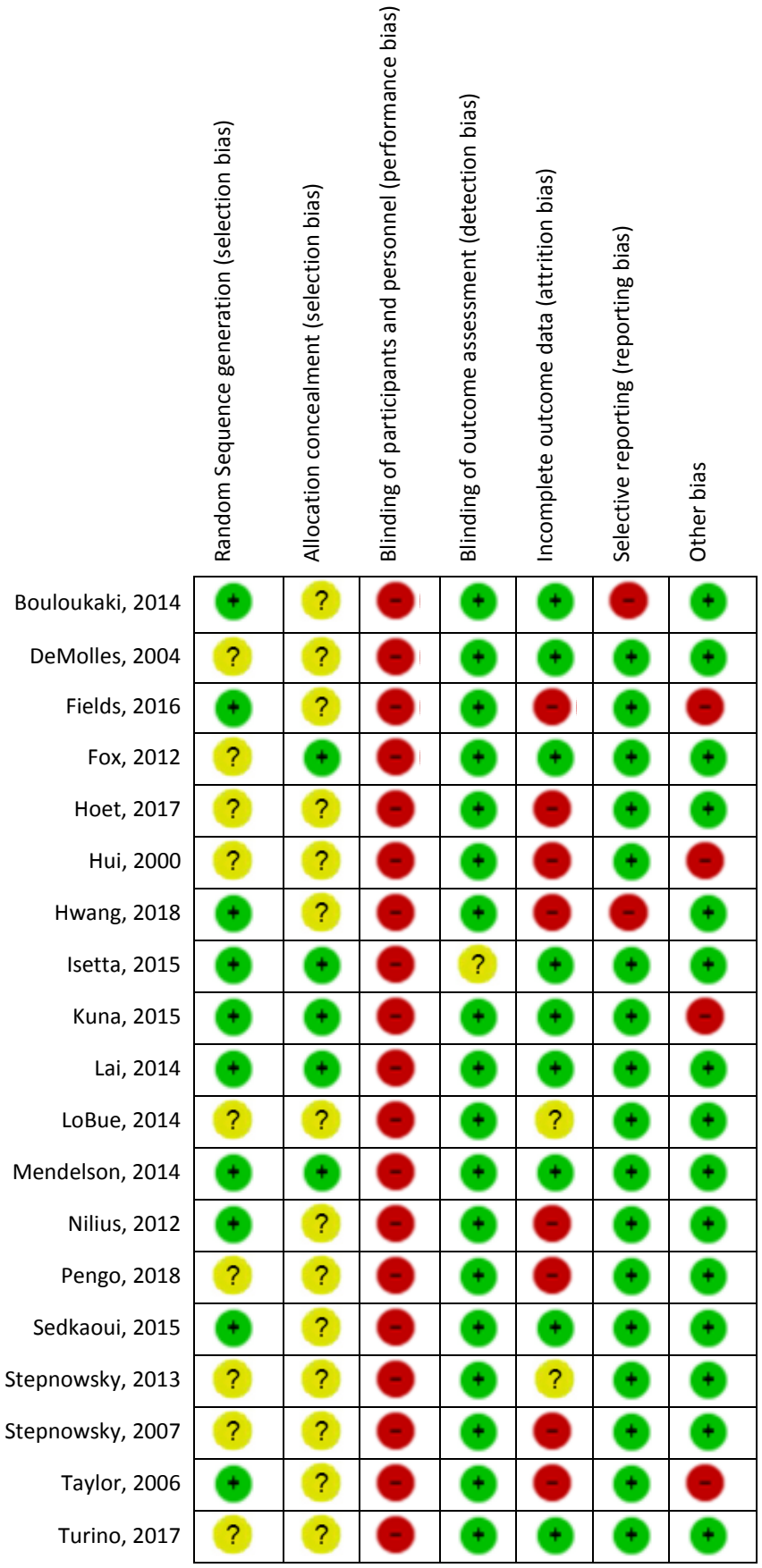


Figure 3: Summary of the risk of bias for all included studies in the review.

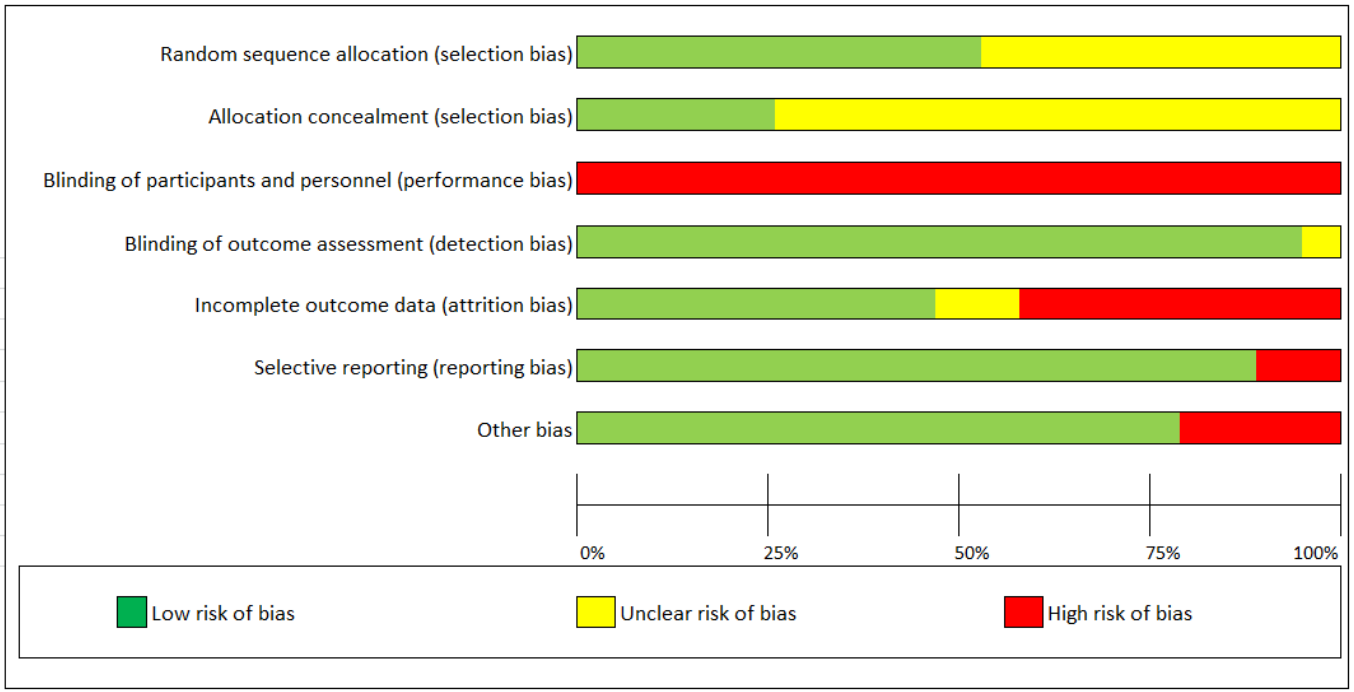
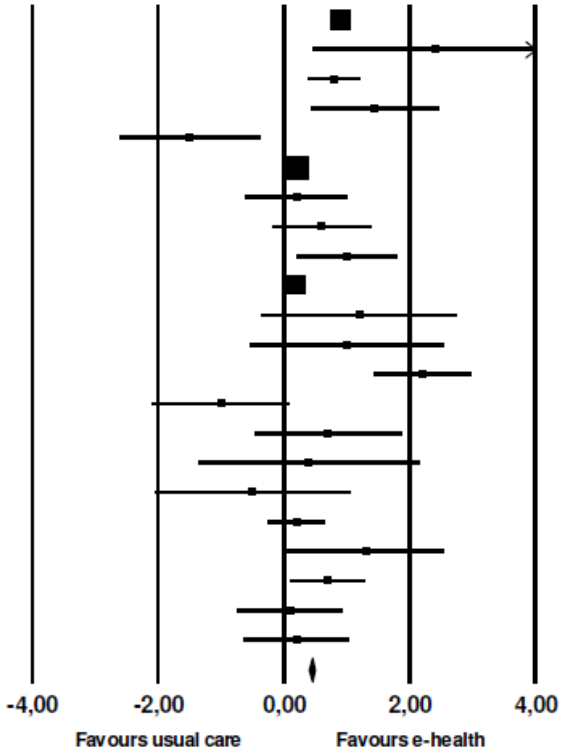


Figure 4: Forest plot of intervention effects on adherence (mean nightly CPAP use in hours).

Study name	Mean difference	Standard error	Variance	95% CI	N	Timepoint
Bouloukaki et al., 2014	0,900	0,045	0,002	0,812 - 0,988	3100	1 month
DeMolles et al., 2004	2,400	0,992	0,984	0,456 - 4,344	30	2 months
Fields et al., 2016	0,800	0,209	0,044	0,390 - 1,210	34	3 months
Fox et al., 2012	1,450	0,526	0,276	0,420 - 2,480	75	3 months
Hoet et al., 2007	-1,500	0,575	0,331	-2,627 - -0,373	37	3 months
Hui et al., 2000	0,200	0,041	0,002	0,120 - 0,280	97	3 months
Hwang et al., 2018(a)	0,200	0,415	0,172	-0,613 - 1,013	206	3 months
Hwang et al., 2018(b)	0,600	0,403	0,162	-0,190 - 1,390	168	3 months
Hwang et al., 2018(c)	1,000	0,410	0,168	0,196 - 1,804	181	3 months
Isetta et al., 2015	0,200	0,051	0,003	0,100 - 0,300	139	6 months
Kuna et al., 2015(d)	1,200	0,794	0,630	-0,356 - 2,756	72	3 months
Kuna et al., 2015(e)	1,000	0,786	0,618	-0,541 - 2,541	66	3 months
Lai et al., 2014	2,200	0,398	0,158	1,420 - 2,980	100	1 month
Mendelson et al., 2014	-1,000	0,561	0,315	-2,100 - 0,100	107	4 months
Nilius et al., 2012	0,700	0,599	0,359	-0,475 - 1,875	76	3 months
Pengo et al., 2017(f)	0,400	0,905	0,818	-1,373 - 2,173	43,5	6 weeks
Pengo et al., 2017(g)	-0,500	0,797	0,636	-2,063 - 1,063	41,5	6 weeks
Sedkaoui et al., 2015	0,200	0,231	0,053	-0,253 - 0,653	379	4 months
Stepnowsky et al., 2007	1,300	0,636	0,404	0,054 - 2,546	40	2 months
Stepnowsky et al., 2013	0,700	0,303	0,092	0,106 - 1,294	241	2 months
Taylor et al., 2006	0,100	0,429	0,184	-0,740 - 0,940	96	1 months
Turino et al., 2017	0,200	0,430	0,185	-0,643 - 1,043	100	3 months
Overall (random model)	0,444	0,025	0,001	0,395 - 0,493	5429	



(a) usual care + Tele-ED: Web–based education
(b) usual care + Tele-mon: Tele-monitoring with automated feedback
(c) usual care + Tele-ED + Tele-mon
(d) usual care + Web-based access to CPAP data
(e) usual care + Web-based access to CPAP data + financial incentive
(f) usual care + Telephone-based positively framed messages
(g) usual care + Telephone-based negatively framed messages

Table 1: Results of main- and subgroup analyses at post-intervention assessment.

Variables	Nr. studies	Nr. comparisons	Total *N*[2]	Mean Difference (95% CI)	*P*-value[3]	I^2 (95% CI)
CPAP adherence[1]	18	22	5429	0.54 (0.29 to 0.79)*	n/a	90.45 (87 to 93)
Outliers excluded	12	14	1433	0.54 (0.27 to 0.82)*	n/a	51.10 (10 to 73)
Subgroup analysis context experimental care					.95	
Add-on to usual care	13	17	4879	0.54 (0.20 to 0.87)*		91.34 (88 to 94)
Replacement of usual care	5	5	550	0.52 (0.13 to 0.91)*		69.10 (21 to 88)
Subgroup analysis type of add-on studies					.71	
e-Support by telephone only	7	8	3867	0.73 (0.27 to 1.20)*		95.58 (93 to 96)
e-Support plus telemonitoring	4	5	561	0.39 (-0.46 to 1.23)		76.98 (44 to 91)
e-Self-monitoring	2	3	245	0.31 (-1.19 to 1.82)		71.66 (4 to 92)

MD = Mean Difference; CPAP = CPAP=Continuous positive airway pressure; ESS = Epworth Sleepiness Scale;

[1] CPAP adherence outcome measure: Average nightly CPAP use in hours

[2] Total sample being analyzed : total randomized *N* in case of intent-to-treat analyses, completers *N* in case of completers analyses

[3] Two-tailed *p*-value reflecting whether difference in effect sizes between the subgroups is significant

* *p*-value is significant at .05 level

n/a = not applicable

Appendix 1: Search string

Search conducted on March 20th, 2018

PsycINFO (EBSCO)

(DE "Compliance" OR DE "Treatment Compliance" OR DE "Treatment dropouts" OR TX("fidelity" OR "complian*" OR "non-complian*" OR "noncomplian*" OR "adheren*" OR "non-adheren*" OR "nonadheren*" OR "dropout*" OR "drop-out*" OR "no-show*" OR "noshow*" OR "attend*" OR "non-attend*" OR "nonattend*" OR "absence*" OR "absent*" OR "non-appear*" OR "nonappear*"))AND (DE "Computer Assisted Therapy" OR DE "Telecommunications Media" OR DE "Electronic Communication" OR DE "Online Social Networks" OR DE "Online Therapy" OR DE "Social Media" OR DE "Telemedicine" OR DE "Text Messaging" OR DE "Computer Mediated Communication" OR DE "Teleconferencing" OR DE "mobile devices" OR DE "communications media" OR DE "cellular phones" OR DE "Internet" OR DE "technology" OR DE "information technology" OR DE "virtual reality" OR DE "computer applications" OR TI("Internet*" OR "Web*" OR "Online*" OR "tele*" OR "electronic*" OR "video*" OR "device*" OR "digital*" OR "software*" OR "mobile*" OR "technolog*" OR "e-health" OR "ehealth" OR "computer*" OR "e-treat*" OR "e-therap*" OR "mhealth" OR "m-health" OR "distance counsel*" OR "cybercounsel*" OR "cyber-counsel*" OR "cyber-treat*" OR "text-messag*" OR "textmessag*" OR "text messag*" OR "SMS*" OR "texting*" OR "short message service*" OR "smartphone*" OR "cell-phone*" OR "cellphone*" OR "cellular phone*" OR "blended*" OR "handheld device*" OR "hand held device*" OR "iPad*" OR "iPhone*" OR "email*" OR "e-mail*" OR "sensor*" OR "wearable*" OR "social media*" OR "social network*" OR "e-counsel*" OR "ecounsel*" OR "palmtop*" OR "telephone*" OR "WhatsApp" OR "Twitter" OR "Facebook" OR "Instagram" OR "forum" OR "chat*" OR "virtual reality*" OR "virtual-reality*" OR "avatar*" OR "Conversational agent*" OR "virtual coach" OR "virtual agent*" OR "embodied agent*" OR "avatar*" OR "relational agent*" OR "interactive agent*" OR "virtual character*" OR "virtual human*" OR "virtual assistant*") OR AB("Internet*" OR "Web*" OR "Online*" OR "tele*" OR "electronic*" OR "video*" OR "device*" OR "digital*" OR "software*" OR "mobile*" OR "technolog*" OR "e-health" OR "ehealth" OR "computer*" OR "e-treat*" OR "e-therap*" OR "mhealth" OR "m-health" OR "distance counsel*" OR "cybercounsel*" OR "cyber-counsel*" OR "cyber-treat*" OR "text-messag*" OR "textmessag*" OR "text messag*" OR "SMS*" OR "texting*" OR "short message service*" OR "smartphone*" OR "cell-phone*" OR "cellphone*" OR "cellular phone*" OR "blended*" OR "handheld device*" OR "hand held device*" OR "iPad*" OR "iPhone*" OR "email*" OR "e-mail*" OR "sensor*" OR "wearable*" OR "social media*" OR "social network*" OR "e-counsel*" OR "ecounsel*" OR "palmtop*" OR OR "telephone*" OR "WhatsApp" OR "Twitter" OR "Facebook" OR "Instagram" OR "forum" OR "chat*" OR "virtual reality*" OR "virtual-reality*" OR "avatar*" OR "Conversational agent*" OR "virtual coach" OR "virtual agent*" OR "embodied agent*" OR "avatar*" OR "relational agent*" OR "interactive agent*" OR "virtual character*" OR "virtual human*" OR "virtual assistant*")) AND (DE "Asthma" OR DE "sleep apnea" OR DE "Chronic obstructive pulmonary disease" OR DE "Pulmonary Emphysema" OR TX("Asthma*" OR "sleep apn*" OR "OSA*" **OR "**hypopnea*" OR "hypopnea*" OR "sleep disordered breath*" OR "COPD" OR "COAD" OR "chronic obstructive*" OR "chronic airflow obstruct*" OR "e**mphysema*" OR "chronic bronchitis" OR "chronic airway obstruct*" OR "obstructive pulmonary disease*" OR "obstructive respiratory disease*" OR "obstructive respiratory tract disease"))**

Filters:

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- Language: English

Pubmed

("Treatment Adherence and Compliance"[Mesh:NoExp] OR "Patient Compliance"[Mesh] OR "Patient Dropouts"[Mesh] OR (fidelity[tiab] OR complian*[tiab] OR non-complian*[tiab] OR noncomplian*[tiab] OR adheren*[tiab] OR non-adheren*[tiab] OR nonadheren*[tiab] OR dropout*[tiab] OR drop-out*[tiab] OR no-show*[tiab] OR noshow*[tiab] OR attend*[tiab] OR non-attend*[tiab] OR nonattend*[tiab] OR absence*[tiab] OR absent*[tiab] OR non-appear*[tiab] OR nonappear*[tiab]))AND ("Telemedicine"[Mesh] OR "Mobile Applications"[Mesh] OR "Social Media"[Mesh] OR "Therapy, Computer-Assisted"[Mesh:NoExp] OR "Drug Therapy, Computer-Assisted"[Mesh:NoExp] OR "Telecommunications"[Mesh:NoExp] OR "Electronic Mail"[Mesh] OR "Videoconferencing"[Mesh] OR "Cell Phone"[Mesh] OR "Distance Counseling"[Mesh] OR "Wearable Electronic Devices"[Mesh] OR "virtual reality"[Mesh] OR (internet*[tiab] OR web*[tiab] OR online*[tiab] OR computer*[tiab] OR electronic*[tiab] OR digital*[tiab] OR ehealth[tiab] OR e-health[tiab] OR e-treat*[tiab] OR e-therap*[tiab] OR mhealth[tiab] OR m-health[tiab] OR distance counsel*[tiab] OR cybercounsel*[tiab] OR cyber-counsel*[tiab] OR text-messag*[tiab] OR textmessag*[tiab] OR text messag*[tiab] OR SMS*[tiab] OR texting*[tiab] OR short message service*[tiab] OR mobile*[tiab] OR smartphone*[tiab] OR cell-phone*[tiab] OR cellphone*[tiab] OR cellular phone*[tiab] OR blended*[tiab] OR software app*[tiab] OR handheld device*[tiab] OR hand held device*[tiab] OR iPad*[tiab] OR iPhone*[tiab] OR email*[tiab] OR e-mail*[tiab] OR sensor*[tiab] OR wearable*[tiab] OR monitoring[tiab] OR social media*[tiab] OR social network*[tiab] OR e-counsel*[tiab] OR ecounsel*[tiab] OR palmtop*[tiab] OR telephone*[tiab] OR WhatsApp[tiab] OR Twitter[tiab] OR Facebook[tiab] OR Instagram[tiab] OR forum[tiab] OR chat*[tiab] OR virtual reality*[tiab] OR virtual-reality*[tiab] OR avatar*[tiab] OR Conversational agent*[tiab] OR virtual coach[tiab] OR virtual agent*[tiab] OR embodied agent*[tiab] OR avatar*[tiab] OR relational agent*[tiab] OR interactive agent*[tiab] OR virtual character*[tiab] OR virtual human*[tiab] OR virtual assistant*[tiab] OR tele-health [tiab] OR telehealth[tiab] OR tele-medicine[tiab] OR telemedicine[tiab] OR tele-care[tiab] OR telecare[tiab] OR tele-psychiatry[tiab] OR telepsychiatry[tiab] OR tele-guid*[tiab] OR teleguid*[tiab] OR tele-based[tiab] OR tele-deliver*[tiab] OR teledeliver*[tiab] OR tele-treat*[tiab] OR teletreat*[tiab] OR tele-therap*[tiab] OR telethera*[tiab] OR tele-intervention*[tiab] OR tele-counsel*[tiab] OR telecounsel*[tiab] OR tele-assist*[tiab] OR teleprevent*[tiab] OR tele-conferenc*[tiab] OR teleconferenc*[tiab] OR tele-monit*[tiab] OR telemonit*[tiab] OR tele-communicat*[tiab] OR telecommunicat*[tiab] OR tele-application*[tiab] OR tele-consult*[tiab] OR teleconsult*[tiab] OR video-guid*[tiab] OR videoguid*[tiab] OR video-mediated[tiab] OR video-based[tiab] OR videobased[tiab] OR video-deliver*[tiab] OR video-treat*[tiab] OR video-therap*[tiab] OR videothera*[tiab] OR video-intervention*[tiab] OR video-counsel*[tiab] OR video-assist*[tiab] OR video-conferenc*[tiab] OR videoconferenc*[tiab] OR video-monit*[tiab] OR videomonit*[tiab] OR video-communicat*[tiab] OR videocommunicat*[tiab] OR video-remind*[tiab] OR video-administered*[tiab] OR video-aided[tiab] OR video-application*[tiab] OR video-consult*[tiab] OR videoconsult*[tiab] OR video-enabled[tiab])) AND ("Asthma"[Mesh] OR "Sleep Apnea, Obstructive"[Mesh:NoExp] OR "Pulmonary Disease, Chronic Obstructive"[Mesh] OR "sleep apnea syndromes"[Mesh:NoExp] OR (Asthma*[tiab] OR sleep apn*[tiab] OR OSA*[tiab] OR hypopnea*[tiab] OR hypopnea*[tiab] OR sleep disordered breath*[tiab] OR sleep-disordered breath*[tiab] OR COPD[tiab] OR COAD[tiab] OR chronic obstructive*[tiab] OR chronic airflow obstruct*[tiab] OR e**mphysema*[tiab] OR chronic bronchitis[tiab] OR chronic airway obstruct*[tiab] OR obstructive pulmonary disease*[tiab] OR obstructive respiratory disease*[tiab] OR obstructive respiratory tract disease***[tiab]))

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- Species: human

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('patient compliance'/exp OR 'adherence'/exp OR 'dropouts'/exp OR 'patient dropout'/exp OR 'patient attendance'/exp OR ('fidelity':ab,ti,kw OR 'complian*':ab,ti,kw OR 'non-complian*':ab,ti,kw OR 'noncomplian*':ab,ti,kw OR 'adheren*':ab,ti,kw OR 'non-adheren*':ab,ti,kw OR 'nonadheren*':ab,ti,kw OR 'dropout*':ab,ti,kw OR 'drop-out*':ab,ti,kw OR 'no-show*':ab,ti,kw OR 'noshow*':ab,ti,kw OR 'attend*':ab,ti,kw OR 'non-attend*':ab,ti,kw OR 'nonattend*':ab,ti,kw OR 'absence*':ab,ti,kw OR 'absent*':ab,ti,kw OR 'non-appear*':ab,ti,kw OR 'nonappear*':ab,ti,kw)) AND ('telemedicine'/exp OR 'telehealth'/exp OR 'e-mail'/exp OR 'mobile phone'/exp OR 'social media'/exp OR 'teleconference'/exp OR 'text messaging'/exp OR 'videoconferencing'/exp OR 'mobile application'/exp OR 'e-counseling'/exp OR 'digital technology'/exp OR 'mobile device'/exp OR 'iphone'/exp OR 'ipad'/exp OR 'computer assisted therapy'/de OR 'monitoring'/exp OR 'personal digital assistant'/exp OR 'wearable sensor'/exp OR 'wearable device'/exp OR 'wearable technology'/exp OR 'virtual reality'/exp OR 'facebook'/exp OR 'twitter'/exp **OR** ('internet*':ab,ti,kw OR 'web*':ab,ti,kw OR 'online*':ab,ti,kw OR 'tele*':ab,ti,kw OR 'video*':ab,ti,kw OR 'computer*':ab,ti,kw OR 'electronic*':ab,ti,kw OR 'digital*':ab,ti,kw OR 'ehealth':ab,ti,kw OR 'e-health':ab,ti,kw OR 'e-treat*':ab,ti,kw OR 'e-therap*':ab,ti,kw OR 'mhealth':ab,ti,kw OR 'm-health':ab,ti,kw OR 'distance counsel*':ab,ti,kw OR 'cybercounsel*':ab,ti,kw OR 'cyber-counsel*':ab,ti,kw OR 'cyber-treat*':ab,ti,kw OR 'text-messag*':ab,ti,kw OR 'textmessag*':ab,ti,kw OR 'text messag*':ab,ti,kw OR 'SMS*':ab,ti,kw OR 'texting*':ab,ti,kw OR 'short message service*':ab,ti,kw OR 'mobile*':ab,ti,kw OR 'smartphone*':ab,ti,kw OR 'cell-phone*':ab,ti,kw OR 'cellphone*':ab,ti,kw OR 'cellular phone*':ab,ti,kw OR 'blended*':ab,ti,kw OR 'software app*':ab,ti,kw OR 'handheld device*':ab,ti,kw OR 'hand held device*':ab,ti,kw OR 'iPad*':ab,ti,kw OR 'iPhone*':ab,ti,kw OR 'email*':ab,ti,kw OR 'e-mail*':ab,ti,kw OR 'sensor*':ab,ti,kw OR 'wearable*':ab,ti,kw OR 'monitoring':ab,ti,kw OR 'social media*':ab,ti,kw OR 'social network*':ab,ti,kw OR 'e-counsel*':ab,ti,kw OR 'ecounsel*':ab,ti,kw OR 'palmtop*':ab,ti,kw OR 'telephone*':ab,ti,kw OR 'WhatsApp':ab,ti,kw OR 'Twitter':ab,ti,kw OR 'Facebook':ab,ti,kw OR 'Instagram':ab,ti,kw OR 'forum':ab,ti,kw OR 'chat*':ab,ti,kw OR 'virtual reality*':ab,ti,kw OR 'virtual-reality*':ab,ti,kw OR 'avatar*':ab,ti,kw OR 'Conversational agent*':ab,ti,kw OR 'virtual coach':ab,ti,kw OR 'virtual agent*':ab,ti,kw OR 'embodied agent*':ab,ti,kw OR 'avatar*':ab,ti,kw OR 'relational agent*':ab,ti,kw OR 'interactive agent*':ab,ti,kw OR 'virtual character*':ab,ti,kw OR 'virtual human*':ab,ti,kw OR 'virtual assistant*':ab,ti,kw)) AND ('Asthma'/exp OR 'chronic bronchitis'/exp OR 'chronic obstructive lung disease'/exp OR 'sleep disordered breathing'/de OR 'sleep apnea syndrome'/exp OR ('Asthma*':ab,ti,kw OR 'sleep apn*':ab,ti,kw OR 'hypopnea*':ab,ti,kw OR 'hypopnoea*':ab,ti,kw OR 'sleep disordered breath*':ab,ti,kw OR 'sleep-disordered breath*':ab,ti,kw OR 'OSA*':ab,ti,kw OR 'COPD':ab,ti,kw OR 'COAD':ab,ti,kw OR 'chronic obstructive*':ab,ti,kw OR 'chronic airflow obstruct***':ab,ti,kw** OR 'e**mphysema*':ab,ti,kw OR 'chronic bronchitis':ab,ti,kw OR 'chronic airway obstruct*':ab,ti,kw OR 'obstructive pulmonary disease*':ab,ti,kw OR 'obstructive respiratory disease*':ab,ti,kw OR 'obstructive respiratory tract disease*':ab,ti,kw))** AND ([article]/lim OR [article in press]/lim OR [editorial]/lim OR [letter]/lim OR [review]/lim) AND ([dutch]/lim OR [english]/lim) AND [humans]/lim AND [embase]/lim AND [2000-2018]/py AND [embase]/lim NOT ([embase]/lim AND [medline]/lim)

Filters:

- Publication Year: 2000-2018
- EMBASE only
- Species: humans
- Language: English or Dutch
- Article type: article in press, article, editorial, review

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([mh “patient compliance”] OR [mh^“treatment adherence and compliance”] OR [mh “Patient dropouts”] OR (‘fidelity’:ab,ti,kw OR ‘complian*’:ab,ti,kw OR ‘non-complian*’:ab,ti,kw OR ‘noncomplian*’:ab,ti,kw OR ‘adheren*’:ab,ti,kw OR ‘non-adheren*’:ab,ti,kw OR ‘nonadheren*’:ab,ti,kw OR ‘dropout*’:ab,ti,kw OR ‘drop-out*’:ab,ti,kw OR ‘no-show*’:ab,ti,kw OR ‘noshow*’:ab,ti,kw OR ‘attend*’:ab,ti,kw OR ‘non-attend*’:ab,ti,kw OR ‘nonattend*’:ab,ti,kw OR ‘absence*’:ab,ti,kw OR ‘absent*’:ab,ti,kw OR ‘non-appear*’:ab,ti,kw OR ‘nonappear*’:ab,ti,kw)) AND ([mh “Telemedicine"] OR [mh "Mobile Applications"] OR [mh "Social Media"] OR [mh^"Therapy, Computer-Assisted"] OR [mh"Drug Therapy, Computer-Assisted"] OR [mh "Telecommunications"] OR [mh "Electronic Mail"] OR [mh "Videoconferencing"] OR [mh "Cell Phone"] OR [mh "Distance Counseling"] OR [mh “Wearable Electronic Devices”] OR [mh “virtual reality”] **OR** (‘internet*’:ab,ti,kw OR ‘web*’:ab,ti,kw OR ‘online*’:ab,ti,kw OR ‘tele*’:ab,ti,kw OR ‘video*’:ab,ti,kw OR ‘computer*’:ab,ti,kw OR ‘electronic*’:ab,ti,kw OR ‘digital*’:ab,ti,kw OR ‘ehealth’:ab,ti,kw OR ‘e-health’:ab,ti,kw OR ‘e-treat*’:ab,ti,kw OR ‘e-therap*’:ab,ti,kw OR ‘mhealth’:ab,ti,kw OR ‘m-health’:ab,ti,kw OR ‘distance counsel*’:ab,ti,kw OR ‘cybercounsel*’:ab,ti,kw OR ‘cyber-counsel*’:ab,ti,kw OR ‘cyber-treat*’:ab,ti,kw OR ‘text-messag*’:ab,ti,kw OR ‘textmessag*’:ab,ti,kw OR ‘text messag*’:ab,ti,kw OR ‘SMS*’:ab,ti,kw OR ‘texting*’:ab,ti,kw OR ‘short message service*’:ab,ti,kw OR ‘mobile*’:ab,ti,kw OR ‘smartphone*’:ab,ti,kw OR ‘cell-phone*’:ab,ti,kw OR ‘cellphone*’:ab,ti,kw OR ‘cellular phone*’:ab,ti,kw OR ‘blended*’:ab,ti,kw OR ‘software app*’:ab,ti,kw OR ‘handheld device*’:ab,ti,kw OR ‘hand held device*’:ab,ti,kw OR ‘iPad*’:ab,ti,kw OR ‘iPhone*’:ab,ti,kw OR ‘email*’:ab,ti,kw OR ‘e-mail*’:ab,ti,kw OR ‘sensor*’:ab,ti,kw OR ‘wearable*’:ab,ti,kw OR ‘monitoring’:ab,ti,kw OR ‘social media*’:ab,ti,kw OR ‘social network*’:ab,ti,kw OR ‘e-counsel*’:ab,ti,kw OR ‘ecounsel*’:ab,ti,kw OR ‘palmtop*’:ab,ti,kw OR ‘telephone*’:ab,ti,kw OR ‘WhatsApp’:ab,ti,kw OR ‘Twitter’:ab,ti,kw OR ‘Facebook’:ab,ti,kw OR ‘Instagram’:ab,ti,kw OR ‘forum’:ab,ti,kw OR ‘chat*’:ab,ti,kw OR ‘virtual reality*’:ab,ti,kw OR ‘virtual-reality*’:ab,ti,kw OR ‘avatar*’:ab,ti,kw OR ‘Conversational agent*’:ab,ti,kw OR ‘virtual coach’:ab,ti,kw OR ‘virtual agent*’:ab,ti,kw OR ‘embodied agent*’:ab,ti,kw OR ‘avatar*’:ab,ti,kw OR ‘relational agent*’:ab,ti,kw OR ‘interactive agent*’:ab,ti,kw OR ‘virtual character*’:ab,ti,kw OR ‘virtual human*’:ab,ti,kw OR ‘virtual assistant*’:ab,ti,kw)) AND ([mh“Asthma”] OR [mh^“obstructive sleep apnea”] OR [mh“Chronic obstructive pulmonary disease”] OR [mh^“sleep apnea syndromes”] OR (‘Asthma*’:ab,ti,kw OR ‘sleep apn*’:ab,ti,kw OR ‘hypopnea*’:ab,ti,kw OR ‘hypopnoea*’:ab,ti,kw OR ‘sleep disordered breath*’:ab,ti,kw OR ‘sleep-disordered breath*’:ab,ti,kw OR ‘OSA*’:ab,ti,kw OR ‘COPD’:ab,ti,kw OR ‘COAD’:ab,ti,kw OR ‘chronic obstructive*’:ab,ti,kw OR ‘chronic airflow obstruct**’:ab,ti,kw** OR ‘e**mphysema*’:ab,ti,kw OR ‘chronic bronchitis’:ab,ti,kw OR ‘chronic airway obstruct*’:ab,ti,kw OR ‘obstructive pulmonary disease*’:ab,ti,kw OR ‘obstructive respiratory disease*’:ab,ti,kw OR ‘obstructive respiratory tract disease*’:ab,ti,kw))**

Filters:

- Publication year 2000-2018
- Word variations have been searched
- Limited to trials only

Appendix 2: Specification of reasons for exclusion regarding OSAS studies (*n* = 37).

- N=5 No randomized controlled design
- N=5 Experimental intervention does not include an E-health component
- N=22 Conference/meeting/symposium abstract
- N=1 Wrong language
- N=4 Control group received the same e-health technology

Study	**Reason exclusion**
Anttalainen et al. 2016	No randomized controlled design
Basoglu et al. 2012	Experimental intervention does not include an E-health component *Note: videotape demonstrated in clinic appointment not considered e-health*
Berry et al. 2014	Conference/meeting/symposium abstract
Chang et al. 2016	Conference/meeting/symposium abstract
Cotton et al. 2012	Conference/meeting/symposium abstract
Didier et al. 2011	Wrong language *Note: French*
Escourrou et al. 2015	Conference/meeting/symposium abstract
Falcone et al. 2014	Experimental intervention does not include an E-health component *Note: chart view on computer screen not considered e-health*
Fox et al. 2010	Conference/meeting/symposium abstract
Frasnelli et al. 2016	No randomized controlled design
Guralnick et al. 2017	Experimental intervention does not include an E-health component *Note: videotape demonstrated in clinic appointment not considered e-health*
Ha et al. 2015	Conference/meeting/symposium abstract
Hardford et al. 2013	No randomized controlled design
Harris et al. 2014	Conference/meeting/symposium abstract
Hood et al. 2013	Control group received the same e-health technology *Note: The e-health component of experimental intervention is also included in the control condition: weekly telephone call is also done in the attention-control group without reminder to send monitoring, but with reminder to weight themselves: only content of call differs between the study groups*
Hostler et al. 2017	No randomized controlled design
Hwang et al. 2014	Conference/meeting/symposium abstract
Isetta et al. 2014	Conference/meeting/symposium abstract
Jean-Louis et al. 2017	Control group received the same e-health technology *Note: Control condition also receives phone calls. Only difference between study conditions is in content of calls, not in e-health delivery.*
Jones et al. 2016	Conference/meeting/symposium abstract
Melkko et al. 2013	Conference/meeting/symposium abstract
Moore et al. 2012	Conference/meeting/symposium abstract

Munafo et al. 2014	Conference/meeting/symposium abstract
Naik et al. 2015	Conference/meeting/symposium abstract
Parikh et al. 2011	No randomized controlled design
Park et al. 2014	Conference/meeting/symposium abstract
Pepin et al. 2014	Conference/meeting/symposium abstract
Richards et al. 2007	Experimental intervention does not include an E-health technology *Note: videotape demonstrated in clinic appointment not considered e-health*
Rodgers et al. 2015	Conference/meeting/symposium abstract
Scala et al. 2012	Conference/meeting/symposium abstract
Sedkaoui et al. 2013	Conference/meeting/symposium abstract
Smith et al. 2006	Control group received the same e-health technology *Note: Control condition also receives telehealth interventions. Only difference between study conditions is in content of tele-health interventions, not in e-health delivery.*
Sparrow et al. 2010	Control group received the same e-health technology *Note: Control condition also receives telemedicine. Only difference between study conditions is in content of telemedicine intervention, not in e-health delivery.*
Stepnowsky et al. 2008	Conference/meeting/symposium abstract
Stepnowsky et al. 2014 a	Conference/meeting/symposium abstract
Stepnowsky et al. 2014 b	Conference/meeting/symposium abstract
Wiese et al. 2005	Experimental intervention does not include an E-health component *Note: videotape demonstrated in clinic appointment not considered e-health*

Appendix 3: An overview of the relevant characteristics of each of the included studies (*n* = 19).

NB: Reference studies #1 to #14 are 'add-on'[1] studies, whereas reference studies #15 to #19 are 'replacement studies'[1].

Study reference #1	
Authors	Bouloukaki et al.
Year of publication	2014
Country	Greece
Study design	
Study conditions (*N*)	- UC (1550) - UC + Intensive follow-up care (1550)
Measurements	- Baseline - 1 Month - 2 Years
Study population	
Age (*M, SD*)	- 55.6 ± 10.2 - 55.1 ± 10.7
Gender (% female)	- 23.0 - 26.9
Target population and recruitment strategy	Adults with OSAHS starting CPAP treatment, recruited through sleep disorders center.
Eligibility criteria	*Inclusion criteria:* - Newly diagnosed OSAHS by PSG according to standard criteria - Moderate- (AHI events/h ≥ 15 but < 30) to severe (AHI events/h ≥ 30) OSAHS - No history of previous CPAP therapy - An above-elementary school education *Exclusion criteria:* - Refusal of CPAP therapy - Central sleep apnea syndromes - Obesity hypoventilation syndrome - Restrictive pulmonary and restrictive chest wall diseases - Severe congestive heart failure - History of life-threatening arrhythmias - Severe cardiomyopathy, - Long-term oxygen therapy - Family or personal history of mental illness or alcohol abuse - Severe cognitive impairment - Concurrent oncological diseases - History of narcolepsy or restless legs syndrome
Diagnostic procedure / OSA definition	AHI ≥ 15 events/h determined by single-night full diagnostic PSG study according to standard techniques, with monitoring of electroencephalogram (EEG), electro-oculogram, electromyogram, flow (by OroNasal thermistor and nasal air pressure transducer), thoracic and abdominal respiratory effort (by respiratory induction plethysmography), oximetry, and body position. PSG recordings were manually interpreted over 30-s periods, by skilled staff, in accordance with the American Academy of Sleep Medicine (AASM) 2007 guidelines. Determination of sleep stages and arousals was performed, according to the AASM 2007 criteria, using EEG montages including frontal, central and occipital leads. The definition of apnea and hypopnea followed the AASM standard criteria.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual follow-up care (see 'control condition') plus: - Additional educational visit with partner or family required to accompany the patient. Visit included 15-minute videotape educational session covering a series of topics about OSAHS and CPAP, followed by a 10–15 min lecture from the sleep clinic's registered nurses to reinforce the key concepts of the education session and the benefits of adherence. - Instructed to complete sleep diary during first month. - Telephone calls (day 2 and day 7) by nurse to check any concerns, problems, and discuss adherence. Home visit if doubting the latter. - Review clinic (day 15 and 30) by sleep specialist, emphasizing adherence and addressing any concerns

Duration & frequency	1 educational session (+-30 minutes), 1-month sleep diary, 2 telephone calls, 2 visits to clinic
Control condition	Usual follow-up care: review visits (15-30 minutes) to clinic after 1 month, at 3-monthly intervals during first year, and every 6 months thereafter. During these visits: clinical assessment, encouragement CPAP use, discussion health issues related to the condition. Compliance data from CPAP device was reviewed and discussed. Any concerns or questions were addressed by CPAP clinic nurse. In addition, a 24-h treatment consultation telephone line to the sleep nurses was open.
Outcome(s)	
Assessment adherence	1) Data measured by real-time clock in CPAP device and uploaded to a computer using specialised software. 2) Self-reported CPAP as recorder in sleep diary during first month of trial
Operationalization adherence	1.1) % nights CPAP used 1.2) nr nights CPAP used a week 1.3) average nightly CPAP use in hours on nights being used 1.4) % regular users, defined as using CPAP for an average of ≥ 4 hours a night on ≥70% of nights
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	2-Year results: 1.1) Sign. (p<.001): 75.1 ± 23.9 VS 88.1 ± 8.2 1.2) Sign. (p<.001): 5.2 ± 2.3. VS 6.2 ± 3.9 1.3) Sign. (p<.001): 5.2 ± 2.2 VS 6.9 ± 1.8 1.4) Sign. (p<.001): 79.8 VS 92.8 1-Month results*:* 1.3) 6.4 ±1.1 VS 7.6 ±1.2 *Note: no significance testing for 1-month results*
Other	
Source of funding and competing interest	-
Study limitations and other comments	-

Study reference #2	
Authors	DeMolles et al.
Year of publication	2004
Country	Massachusetts, United States
Study design	
Study conditions (*N*)	- UC (15) - UC + Telephone-linked communication (15)
Measurements	- Baseline - 2 Months
Study population	
Age (*M, SD*)	- 42.0 ± 13.0 - 49.8 ± 15.7
Gender (% female)	n/a
Target population and recruitment strategy	Adults with OSAS starting CPAP treatment, recruited through collaborating home care company.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - English-speaking - Have a physician diagnosis of OSAS - Have PSG demonstrating AHI ≥ 15 events/h of sleep *Exclusion criteria:* - Reported prior CPAP use
Diagnostic procedure / OSA definition	PSG demonstrating AHI ≥ 15 events/h
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Computer-based telephone-linked communication (TLC) technology, i.e. interactive voice response system
Type intervention	Usual medical follow-up care (see 'control condition') plus: Automated TLC monitoring of patients' self-reported behavior, and providing education and reinforcement through a structured dialogue. The content of the TLC was based on patterns of CPAP adherence (i.e. low adherence defined as nonuse of the CPAP, use for fewer than 4 hours per night on nights using CPAP, or use fewer than 5 nights per week (or fewer than 2 nights in the case of the 3-day call) and side-effect profiles. Routine printed reports with information on the frequency and duration of CPAP use, side effects, and OSAS symptoms, were sent to the patients' physicians biweekly or in case of low adherence or side-effects.
Duration & frequency	1 call after 3 days, where after weekly call for period of 2 months. Routine printed reports to physician biweekly or in case of non-adherence.
Control condition	Usual follow-up care: not further specified.
Outcome(s)	
Assessment adherence	Pressure-time meters installed in CPAP machines.
Operationalization adherence	Average nightly CPAP use in hours over 2-month period.
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	Non-sign. (*p*=.08): 2.9 ± 2.4 VS 4.4 ± 3.0
Other	
Source of funding and competing interest	Supported by the VA Health Services Research and Development Service.
Study limitations and other comments	-

Study reference #3	
Authors	Fox et al.
Year of publication	2006
Country	Canada
Study design	
Study conditions (*N*)	- UC (n=36) - UC + Telemonitoring (n=39)
Measurements	- Baseline - 3 Months
Study population	
Age (*M, SD*)	- 55.2 ± 11.5 - 52.0 ± 10.8
Gender (% female)	- 22.2 - 18.0
Target population and recruitment strategy	Adults with moderate-to-severe OSA starting CPAP treatment, recruited through university sleep disorders program.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 19 years - Moderate to severe OSA (AHI ≥ 15 events/hr as demonstrated by PSG) - Prescribed CPAP by regular sleep physician *Exclusion criteria:* - Active cardiopulmonary or psychiatric disease - Previously treated for OSA - Not having a telephone line in their bedroom - Not being able to return for follow-up visits.
Diagnostic procedure / OSA definition	AHI ≥ 15 events/hr using the Chicago scoring criteria for the determination of apneas and hypopneas, according to the American Academy of Sleep Medicine. Diagnoses were made by respirologists by an overnight PSG.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telemonitoring, web-based portal, telephone (as-needed).
Type intervention	Usual follow-up care (see 'control condition') plus: Automated weekly telemonitoring of CPAP adherence, applied CPAP pressure, mask leaks, and residual AHI events were transferred daily to a website. Research coordinator reviewed this data weekly and contacted the patient by telephone in case of: mask leak > 40 L/min for greater than 30% of the night, < 4 hr of use for two consecutive nights, machine measured AHI > 10 events/h, and 90th percentile of pressure > 16 cm H2O. Within these calls, coordinator would inquire symptoms, arrange talk or visit with PAP coordinator if necessary, and deliver interventions to improve compliance (e.g. a different mask, chin strap, modifications of pressure settings, modifications of humidifier settings, saline nasal sprays).
Duration & frequency	Weekly telemonitoring with subsequent phone call as needed (see 'type intervention') over 3-month period.
Control condition	Usual follow-up care: phone call 2 days after starting CPAP treatment to ask about progress, adherence, and any problems with the machine encountered. Return visit after 4-6 weeks with PAP coordinator and doctor, and PAP data were downloaded from patients' machines (i.e. PAP adherence, applied PAP pressure, mask leak, and residual respiratory events). Any problems with treatment were addressed at this time. Return visit after 8 weeks for downloading PAP data only. Return visit after 3 months for downloading data and seeing sleep specialist.
Outcome(s)	
Assessment adherence	A modem attached to the CPAP device (REMstar® Pro nasal CPAP device (Phillips Respironics Inc., Murrysville, PA)) was programmed to send physiologic information directly to a web-based database across the telephone line each morning.
Operationalization adherence	1) Mean % nights CPAP used 2) Mean nightly CPAP use in minutes 3) Mean nightly CPAP use in minutes on nights being used
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Non-sign. (p=.19): 45.9 ± 38.0 VS 55.9 ± 40.0 2) Sign. (p=.006): 105 ± 118 VS 191 ± 147 3) Sign. (p<.0001): 207 ± 106 VS 321 ± 80

Other	
Source of funding and competing interest	This study was partially supported by a research grant from Phillips Respironics Inc.
Study limitations and other comments	Adherence in UC was low (1.75 hr/night). Low adherence in UC might be explained by low baseline Epworth Sleepiness Scale Scores (ESS), suggesting that our patients were not particularly sleepy. Indeed, adherence was much greater in both study arms when only patients with a baseline ESS of 11 or greater were included.

Study reference #4	
Authors	Hoet et al.
Year of publication	2007
Country	Belgium
Study design	
Study conditions (*N*)	- UC (n=23, analyses conducted on subsample n=20) - UC + Telemonitoring (n=23, analyses conducted on subsample n=17)
Measurements	- Baseline - 3 Months
Study population	
Age (*M, SD*)	- 54.0 ± 14.0 - 59.0 ± 13.0
Gender (% female)	- 43.0 - 83.0 *
Target population and recruitment strategy	Adults with OSAS starting CPAP treatment, recruited through sleeping unit of a university hospital.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - Recently diagnosed with OSAS with an AHI ≥ 20 events/h *Exclusion criteria:* - Previous exposure to CPAP therapy - Mixed or predominantly central sleep apnea - A planned trip abroad for > 3 weeks during the first 3 months of follow-up - Language barriers - Cognitive or psychiatric disorders making it difficult to comprehend information regarding CPAP therapy and provide informed consent - Significant comorbidities such as severe COPD or hypoventilation syndromes
Diagnostic procedure / OSA definition	AHI ≥ 20 events/h according to the American Academy of Sleep Medicine 2012 scoring rules, as determined by an overnight PSG.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telemonitoring, web-based portal, telephone (as-needed).
Type intervention	Usual follow-up care (see 'control condition') plus: Automated telemonitoring of CPAP usage data, masks leaks, CPAP pressure, and residual apnea-hypopnea index. Analysis of patient data through web portal, and call and set-up visit in case of air leaks, low apnea-hypopnea index, or low adherence to CPAP.
Duration & frequency	Daily telemonitoring and 2-weekly analysis of patient usage data over 3- month period.
Control condition	Usual follow-up care: written CPAP treatment instructions and the ability to contact sleep unit as often as needed in order to resolve problems regarding CPAP use. Also, 1-month CPAP treatment group-educational session, and a 1.5- and 3-month visit to the pneumologist.
Outcome(s)	
Assessment adherence	Telemonitoring throughT4P (SRETT medical, France), transmission of CPAP data through General Packet Radio Service (GPRS) network. Data sent to secured server and analyzed onT4P Vision Web Portal. For UC participants, CPAP data was collected and analyzed by software Rescan from Resmed.
Operationalization adherence	1) Mean nightly CPAP use in hours 2) Total number of hours CPAP use
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Sign. (p=.02): 5.7 ± 1.6 VS 4.2 ± 1.9 2) Sign. (p=.03): 507 ± 205 VS 387 ± 185
Other	
Source of funding and competing interest	This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Study limitations and other comments	Limited sample size / power.

Study reference #5	
Authors	Hui et al.
Year of publication	2000
Country	China
Study design	
Study conditions (*N*)	- UC: Basic CPAP education and support (n=54, 3-month analyses conducted on subsample n=52) - UC + Augmented CPAP education and support (n=54, 3-month analyses conducted on subsample n=45)
Measurements	- Baseline - 1 Month - 3 Months
Study population	
Age (*M, SD*)	45 ± 11
Gender (% female)	10.2
Target population and recruitment strategy	Adults with OSA starting CPAP treatment, recruited through a respiratory and sleep clinic in a university hospital.
Eligibility criteria	*Inclusion criteria:* - Consecutive, symptomatic patients with newly diagnosed OSA commencing nasal CPAP treatment
Diagnostic procedure / OSA definition	AHI ≥ 10 events per hour of sleep as shown by overnight PSG, plus self-reported sleepiness. Sleep stages were scored according to standard criteria by Rechtschaffen and Kales. Apnea was defined as cessation of airflow for > 10 seconds, and hypopnea was defined as a reduction of airflow ≥ 50% for >10 seconds plus an oxygen desaturation of > 4% or an arousal.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Basic CPAP education support (see 'control ondition') plus: extra education by 15-minute videotape by physician followed by additional educational session by respiratory nurses. Also, telephone support by nurses (day 1, day 2, and at weeks 1, 2, 3, 4, 8, and 12) to help sort out any technical problem and encourage the use of CPAP. Finally, early face-to-face reviews by physician at weeks 1 and 2.
Duration & frequency	Video and additional educational session each 15 minutes.
Control condition	Basic CPAP education and follow-up support: 10-min CPAP education program by a respiratory nurse, in which patients also received a brochure on OSA and CPAP treatment in Chinese. Follow-up by physicians and nurses at the CPAP clinic at 1 and 3 months to deal with any problem with the CPAP device or mask fit, and CPAP pressure was adjusted if necessary.
Outcome(s)	
Assessment adherence	Microprocessor with dual time meters recorded both CPAP machine run time and time spent at effective pressure (measured by a mask pressure transducer recorder). Adherence data were downloaded into a personal computer using the Respironics Encore software (Respironics).
Operationalization adherence	1) Subjective/self-report: Average nightly CPAP use in hours 2) Objective (see column above): Average nightly CPAP use in hours spent at effective pressure 3) Objective (see column above): % of participants using their CPAP machine for more than 4 hours per night for 70% of the nights.
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) 1-Month: non-sign. (p=.5): 6.4 ± 0.2 VS 6.6 ± 0.2 3-Month: non-sign. (p=.6): 6.5 ± 0.2 VS 6.3 ± 0.2 2) 1-Month: non-sign. (p=.4): 5.3 ± 0.2 VS 5.5 ± 0.2 3-Month: non-sign. (p=.98): 5.3 ± 0.3 VS 5.3 ± 0.2 3) 1-Month: non-sign. (p=.15): 71 ± 4 VS 79 ± 4 3-Month: non-sign. (p=.6): 71 ± 4 VS 74 ± 4
Other	
Source of funding and competing interest	-
Study limitations and other comments	Baseline differences sleepiness (Epworth Sleepiness Scale): higher in augmented support condition. There was also a technical failure with the Aria/Encore software, resulting in missing CPAP compliance data for 2 patients in the control group and 9 in the augmented support group at 12 weeks.

Study reference #6	
Authors	Hwang et al.
Year of publication	2018
Country	California, United States
Study design	
Study conditions (*N*)	- UC (n=354, analyses conducted on subsample n=129) - UC + Tel-ED (n=380, analyses conducted on subsample n=163): telemedicine web–based education - UC + Tel-TM (n=375, analyses conducted on subsample n=125): CPAP telemonitoring with automated patient usage feedback - UC + Tele-both (n=346, analyses conducted on subsample n=138): web-based education plus telemonitoring with automated patient feedback
Measurements	- Baseline - 3 Months
Study population	
Age (*M, SD*)	49.± 12.5
Gender (% female)	51.0
Target population and recruitment strategy	Adults with OSA who were prescribed CPAP, recruited through sleep center that served large medical center.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - No previous sleep testing or trial of OSA therapy - Eligible for home sleep apnea testing (HSAT) *Exclusion criteria:* - At risk of other sleep disorders (e.g., severe insomnia) - Significant cardiopulmonary disease (e.g., heart failure, chronic respiratory failure) - English not indicated as their preferred language
Diagnostic procedure / OSA definition	AHI ≥ 5 events per hour. Sleep medicine physician triaged appropriate patients to HSAT after review of the referral information and electronic health record chart. HSAT classes (up to 13 people) were led by a sleep trained respiratory therapist and sleep technologist and provided interactive OSA education and individualized HSAT setup. After a one-night test, each patient returned for an individual appointment with a respiratory therapist to review the results in terms of OSA diagnosis.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	- Tel-ED: Web-based education portal - Tel-TM: Telemonitoring unit & interactive voice response/automated feedback messaging platform, delivering feedback messages to the patients by means of phone call, text messaging, or email (patient choice) - Tel-Both: Both Tel-ED and Tel-TM
Type intervention	- Tel-ED: usual care and follow-up care (see 'control condition') plus: Two interactive telemedicine educational programs. The first program was e-mailed 2 weeks before the 1-hour group education class, and was about pathophysiology of OSA (including animated videos depicting airway narrowing), health-related risks and impact on daytime vigilance, introduction to CPAP therapy, and details of the assessment process. After confirming OSA diagnosis by home sleep apnea test, OSA, a link to the second education program was e-mailed during their 1-week CPAP trial, focused on how to properly use CPAP, potential benefits on health and daytime vigilance, methods of acclimating, and equipment care instructions. - Tel-TM: usual care and follow-up care (see 'control condition') plus: automated daily telemonitoring and platform triggering automated feedback via text messaging, phone calls, e-mail, or combination of these (patient preference) when CPAP usage thresholds were met (see column 'duration and frequency'). Messages were automatically sent and provided encouragement to improve use or positively reinforcing successful adherence. - Tel-Both: Both the Tel-ED and Tel-TM as described above.
Duration & frequency	- Tel-ED: Two web-based education programs of 15 minutes each, - Tel-TM: Daily telemonitoring and automated feedback over 3-month period. Usage thresholds for messages: 1) no CPAP data for 3 consecutive days, 2) CPAP usage <4h for 3 consecutive nights, and 3) a 30-day period during the first 3 months of therapy in which CPAP use was >4 h/night on >70% of days (i.e. Medicare definition of adherence).

Control condition	Usual care and follow-up care: 1-hour small group education class about OSA, home sleep apnea test, and CPAP treatment. After a trial of CPAP treatment for 1 week, those willing to continue CPAP were prescribed therapy and scheduled for a 3-month follow-up appointment.
Outcome(s)	
Assessment adherence	Autotitrating device (AirSense 10; ResMed Corp) wirelessly transmitted CPAP data daily via a cellular signal into a cloud database (U-Sleep; ResMed Corp).
Operationalization adherence	Primary outcomes: 1) Number of nights CPAP use 2) Average nightly CPAP use in hours on all nights Secondary outcomes: 3) % of nights using CPAP 4) % of nights using CPAP for > 4 hours a night 5) Average nightly CPAP use in hours on nights being used
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	2) Non-sign. (p1=.10), Sign. (p2=.0002), Sign. (p3=.0002): 3.8 ± 2.5 VS 4.0 ± 2.4 VS 4.4 ± 2.2 VS 4.8 ± 2.3 3) Non-sign. (p1=.28), Sign. (p2<.0001), Sign. (p3=.0004): 64.8 ± 34.2 VS 68.6 ± 31.3 VS 76.6 ± 28.3 VS 78.3 ± 28.3 5) Non-sign. (p1=.13), Sign. (p2=.006), Sign. (p3=.003): 5.2 ± 1.8 VS 5.2 ± 1.8 VS 5.3 ± 1.7 VS 5.8 ± 1.6 *Note 1: P-values compare estimated means from each intervention group (p1=Tele-ED, p2=Tele-TM, p3=Tele-both) to UC.* *Note 2: Only between-group effects of experimental conditions versus UC are reported on, whereas not being compared to each other*
Other	
Source of funding and competing interest	-
Study limitations and other comments	Selective outcome reporting (see 'operationalization adherence' and 'results').

Study reference #7	
Authors	Kuna et al.
Year of publication	2015
Country	Pennsylvania, United States
Study design	
Study conditions (*N*)	- UC (n=52) - UC + Web-based access CPAP data (n=46) - UC + Web-based access CPAP data + financial incentive (n=40)
Measurements	- Baseline - 1 Week - 3 Months
Study population	
Age (*M, SD*)	50.9 ± 12.1
Gender (% female)	39.0
Target population and recruitment strategy	Adults with OSA starting PAP treatment, recruited through sleep centers at 4 hospitals/medical centers.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - Prescribed PAP treatment for newly diagnosed OSA with an AHI of ≥ 10 events/h on in-laboratory PSG - Access to a telephone and the Internet on all days of the week. - Stable medical history in previous 2 months: no hospitalizations or new medical diagnoses other than OSA - No change in medications and no regular use (> 3 times per week) of sedative or hypnotic medications in the previous 2 months *Exclusion criteria:* - Diagnosis of another sleep disorder in addition to OSA - Previous medical or surgical treatment for OSA - Required supplemental oxygen or bilevel PAP treatment - Worked rotating or night shift in the past 3 months - Claustrophobia or facial pathology that prevented PAP treatment. - Recent change in medication(s)
Diagnostic procedure / OSA definition	AHI ≥ 10 events/h on in-laboratory PSG. The PSGs were scored and interpreted by the sleep center staff at each clinical site using American Academy of Sleep Medicine recommended criteria.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Web-based portal with CPAP data access
Type intervention	- Usual care (see 'control condition') plus Web-based access to CPAP data: Ability to log into website at any time throughout the 3-month period to view a numerical and bar graph display of daily hours of PAP use (i.e., mask-on time), both from the beginning of treatment and over the previous 2 weeks of treatment. When logging in, patients were asked to indicate (yes/no) if they had used the treatment for ≥4 hours in the past 24 h. This response was used to verify that they had logged into the website on a particular day. - Financial incentive: Participants were informed that they could earn $30 for each day in the 1st week that they logged into the website and had used PAP treatment for ≥4 hours in the previous night (max. first week $210). Payment was made at the end of the first week of treatment.
Duration & frequency	Web access to CPAP usage data over period of 3 months.
Control condition	Usual follow-up care at sleep centers: 1 clinic visit with the sleep specialist within 1 to 3 months of starting treatment. During this visit, specialist had access to PAP website for clinical management, and could share PAP information with the patient. The home health care company supplying the PAP equipment conducted routine follow-up care during the 3-month intervention, which generally consisted of a phone call to the patient at 1 week, 1 month, and 3 months. In case of mask or equipment problems, the home healthcare company provided routine clinical care. Finally, all participants completed questionnaires at baseline, and 1 and 3 months, for which they received $30 each.
Outcome(s)	
Assessment adherence	Adherence data was transmitted from APAP and CPAP devices (System One, Philips Respironics, Inc, Murrysville, PA) equipped with a wireless modem. On a daily basis, the modem transmitted data from the PAP unit to the manufacturer's server, which in turn exported the results to the Way to Health website.

Operationalization adherence	1) Mean nightly CPAP use in hours 2) Mean nights used 3) Mean nightly CPAP use in hours on nights being used
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1-Week results: 1) Sign. (p1<.0001 & p2<.0001): 4.7 ± 3.3 VS 6.3 ± 2.5 VS 5.9 ± 2.5 2) Sign. (p1<.0001 & p2=.005): 5.5 ± 2.6 VS 6.7 ± 0.8 VS 6.6 ± 1.3 3) Sign. (p1=.002) & Non-Sign. (p2=.13): 6.0 ± 2.4 VS 6.6 ± 2.2 VS 6.3 ± 2.0 3-Month results: 1) Sign. (p1=<.0001 & p2=<.0001): 3.8 ± 3.3 VS 5.0 ± 3.2 VS 4.8 ± 3.0 2) Sign. (p1=<.0001 & p2=<.0001): 4.7 ± 3.0 VS 5.6 ± 2.3 VS 5.6 ± 2.3 3) Sign. (p1=<.0001 & p2=<.0001): 5.6 ± 2.4 VS 6.2 ± 2.3 VS 5.9 ± 2.0 *Note: P-values compare estimated means from each intervention group (p1=Web access and p2=Web access with financial incentive) to usual care*
Other	
Source of funding and competing interest	Funding: NIH RC2-AG036592-01; NIH 1P01-1HL094307. P'unk Ave, Inc., a Web-based software company in Philadelphia, PA, created the Way to Health website for the University of Pennsylvania and continued to support the website during the project. First and fourth author received grant support from Philips Respironics. Last author was a Principal at VAL Health (Philadelphia, PA). Eleventh author has received research support from Humana, Weight Watchers, and CVS, and has consulted for Val Health.
Study limitations and other comments	About 80% of subjects in UC and UC + web-access to CPAP data groups were treated with APAP instead of CPAP, whereas APAP was used in 62% of participants in UC+ web-access to CPAP data + financial incentive group. A greater % of participants with VS without the financial incentive viewed their PAP data in 1st week. This suggests participants in the financial incentive group to be aware of the requirements to qualify for reward. Possibly, the relatively higher adherence in participants with Web access but without financial incentive may have resulted in a 'ceiling effect' that prevented the financial incentive from having any additional benefit. Finally, the two experimental interventions were not statistically compared.

Study reference #8	
Authors	Lai et al.
Year of publication	2014
Country	China
Study design	
Study conditions (*N*)	- UC (n=51) - UC + brief motivational enhancement education program (n=49)
Measurements	- Baseline - 1 Week - 1 Month - 3 Months
Study population	
Age (*M, SD*)	- 51 ± 10 - 53 ± 10
Gender (% female)	- 82.3 - 83.7
Target population and recruitment strategy	Adults with OSA starting CPAP treatment, recruited through sleep disorder center in hospital.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - Newly diagnosed OSA (AHI ≥ 5) - Receiving in-laboratory auto-CPAP titration for the first time - No prior OSA or CPAP education classes. *Exclusion criteria:* - Central sleep apnea - Periodic leg movement disorders - Coexisting COPD - Pregnancy - Psychiatric illness on treatment - Cognitive impairment - Illiteracy - Unstable health conditions, e.g. end-stage renal failure on renal replacement therapy, malignancy currently on radiotherapy or chemotherapy, or dependence in daily care - Unable to attend the education session before discharge from sleep disorders center after CPAP titration - Scheduled for OSA follow-up in other hospitals - Participating in another clinical trial
Diagnostic procedure / OSA definition	AHI ≥ 5 as shown by overnight CPAP titration procedure. *Note: randomization was stratified into three severity groups: AHI ≥ 5, AHI ≥ 15 and < 30, and AHI > 30*
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual care (see 'control condition') plus brief motivational enhancement education program directed at enhancing that patients' perception of the risk of OSA, confidence in the ability to apply CPAP treatment (self-efficacy), and association of their behavior to the desired outcome (adherence) or outcome expectancy. Program included 25-min video and a booklet providing information and education including real-life experience of CPAP user. Also, 20-minute patient-centered interview was conducted based on motivational interviewing techniques: (1) using importance and confidence rulers to explore the barriers and facilitators of using CPAP (2) using a decision matrix to discuss the positive and negative aspects of using or not using CPAP (3) looking forward to the expected outcomes or benefits of using CPAP. Finally, 10-minute telephone follow-up to provide early review at day 2 of CPAP treatment (e.g. ask about experiences CPAP, discuss any problems encountered, highlight positive changes, encouraging adherence).
Duration & frequency	Video and motivational interview (25 & 20 minutes respectively), plus 1 telephone call after 2 days
Control condition	Usual care comprised training/education session (30-minutes) and advice (15 minutes) on OSA and CPAP treatment.
Outcome(s)	
Assessment adherence	Adherence data was downloaded from CPAP devices with software.

Operationalization adherence	Primary outcome: 1) Mean nightly CPAP use in hours Secondary outcomes: 2) % adherers, with adherent defined as using CPAP for ≥4 hours a night on at least 70% of nights 3) Intention to use: % nights on which CPAP has been switched on 4) Usage index: % days nights CPAP for at least 4 hours a night
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Sign. (p<.001): 2.9 ± 2.5 VS 5.5 ± 1.8 (1 week), 2.6 ± 2.3 VS 4.8 ± 1.6 (1 month), 2.4 ± 2.3 VS 4.4 ± 1.8 (3 months) 2) Sign. (p<.001): 15 ± 29 VS 32 ± 63 (1 week), 10 ± 20 VS 30 ± 59 (1 month), 10 ± 20 VS 20 ± 41 (3 months) 3) Sign. (p<.001): 59 ± 36 VS 89 ± 19 (1 week), 52 ± 36 VS 84 ± 20 (1 month), 46 ± 36 VS 79 ± 23 (3 months) 4) Sign. (p<.001): 39 ± 38 VS 74 ± 29 (1 week), 34 ± 33 VS 70 ± 26 (1 month), 32 ± 32 VS 61 ± 28 (3 months)
Other	
Source of funding and competing interest	Conflicts of interest: Dr Lai has been sponsored to attend Sleep and Breathing Conference 2013 and 18th Congress of the Asian Pacific Society of Respirology by ResMed and Koninklijke Philips N.V ., respectively. Dr Lam has been sponsored to attend World Sleep Conference 2011, World Congress of Sleep Apnea 2012, and Sleep and Breathing Conference 2013 by ResMed, Koninklijke Philips N.V., and Homecare Medical Ltd, respectively. Dr Weaver is the member of the board of directors of ViMedicus, Inc. She has received research support from Teva Pharmaceuticals Industries, Ltd and has received equipment for her research from Koninklijke Philips N.V. She has been a consultant for Apnex Medical, Inc, and has received royalty fees for use of the Functional Outcomes of Sleep Questionnaire from NovaSom, Apnex Medical, Inc, GlaxoSmithKline, Koninklijke Philips N.V.,Cephalon, Inc (now Teva Pharmaceuticals Industries, Ltd), and Nova Nordisk. Dr Ip has received honoraria from Koninklijke Philips N.V. for a lecture in World Sleep 2011 and a lecture at Kyoto University in 2011.
Study limitations and other comments	Statistics on time contrasts not reported (only whole study period, hence no between group comparisons for 1 week, 1 month, and 3 months, only whole study period), and no other statistics than p-value and confidence intervals reported. Restricted eligibility criteria.

Study reference #9	
Authors	Lo Bue et al.
Year of publication	2014
Country	Italy
Study design	
Study conditions (*N*)	- UC (n=20, 12-month-analyses conducted on subsample n=18) - UC + Extra early support (n=20, 12-month-analyses conducted on subsample n=19)
Measurements	- Baseline - 3 Months - 6 Months - 12 Months
Study population	
Age (*M, SD*)	- 55.7 ± 8.3 - 58.6 ± 13.2
Gender (% female)	32.5
Target population and recruitment strategy	Adults with OSA and indication to CPAP treatment, recruited through sleep disordered breathing center of IBIM-CNR Institute of Biomedicine and Molecular Immunology (IBIM), National Research Council.
Eligibility criteria	*Inclusion criteria:* - Aged >18 years - Diagnosis of OSA - Indication for CPAP treatment according to international guidelines (incl. American Sleep Disorders Association) *Exclusion criteria:* - Impairments or comorbidities considered likely to interfere with adherence to instructions: neuromuscular disease, unstable psychiatric disease or cognitive impairment, myocardial infarction, unstable angina, cardiac failure, cerebrovascular accident, lung disease with awake resting oxygen saturation of less than 90%.
Diagnostic procedure / OSA definition	Apneas were identified on the airflow signal, and were classified as obstructive, central, or mixed, according to behavior of thoraco-abdominal movements. Hypopneas were scored when a ≥30% reduction in the airflow signal was detected in association with a reduction ≥4% of oxyhemoglobin saturation (SaO2). AHI was calculated as the number of (apneas + hypopneas)/h of recording that was analyzed. Time with SaO2 below 90% (TSat ≤90%) was calculated.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual follow-up care (see 'control condition') plus: Standardized daily telephone interview from sleep doctor in first week and after 1 month. During the interview patients were asked about the most common adverse events during CPAP treatment. Doctor reviewed progress and gave advice to manage CPAP-related adverse effects, and encouraged to maintain adherence to therapy. Besides, when necessary, technical support was given by the home care provider.
Duration & frequency	Two standardized daily telephone interviews at day 1 and 30.
Control condition	Usual follow-up care: Patients were provided with a telephone number to call the doctor of the sleep center for support within office hours. The home care provider visited all patients at their home at month 3, 6, 12 from the start of therapy, and each time downloaded data from the device memory (time of device use per night), conducted other assessments, and transmitted all data to the sleep center.
Outcome(s)	
Assessment adherence	Adherence data was downloaded from CPAP machines (Weinmann SOMNOcomfort 2e)
Operationalization adherence	1) Mean nightly CPAP use in hours 2) Monthly average number of nights of CPAP therapy ≥ 4 hours 3) % adherence (adherent defined as CPAP use ≥ 4 hours a night for at least 70% of the nights
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1-Year results: 1) Non-sign. (p-value not reported): 3.8 VS 4.3 1-Month results: 2) Sign. (p=.02): 16.0 VS 23.2 3) Sign. (p-value not reported): 55.7 VS 77.5 *Note: 1-month differences in adherence became non-significant at the 2nd, 3rd month and at the 2nd (3) 58.3 VS 66.7), 3rd and 4th quarter (3) 56.3 VS 54.3) (statistics not provided).*

Other	
Source of funding and competing interest	Supported by the Italian National Research Council order numbers ME. P01.014.002 and ME.P01.014.009.
Study limitations and other comments	-

Study reference #10	
Authors	Mendelson et al.
Year of publication	2014
Country	France
Study design	
Study conditions (*N*)	- UC (n=53) - UC + Telemedicine care (n=54)
Measurements	- Baseline - 1 Month - 4 Months
Study population	
Age (*M, SD*)	63 ± 9
Gender (% female)	16.8
Target population and recruitment strategy	Adults with OSA with high cardiovascular risk starting CPAP, recruited through referrals from multiple sleep centers by general practitioners and hospital specialists.
Eligibility criteria	*Inclusion criteria:* - Aged 18-85 years old - Diagnosed OSA (AHI > 15 events an hour) - BMI < 40 - Cardiovascular risk SCORE > 5% or being in secondary prevention with a past history of cardiovascular disease (transient ischemic attack, stroke, cerebral hemorrhage, myocardial infarction, angina, coronary revascularization, arteriopathy, aortic aneurism) *Exclusion criteria:* - Central sleep apnea syndrome - Cardiovascular score < 5% - Cardiac failure - History of hypercapnic chronic respiratory failure - Incapacitated patients - Pregnancy in accordance with article L 1121-6 of the French public health code - Taking part in another clinical trial
Diagnostic procedure / OSA definition	AHI ≥ 15 events per hour of sleep. OSA diagnosis was obtained by full PSG or by simplified polygraph without electroencephalogram (EEG) recordings. Sleep was scored manually according to standard criteria. PSG used continuous acquisition of the following recordings: electroculogram (EOG; 3 channels), EEG (3 channels), electromyogram (1 channel) and electrocardiogram (1 channel). Airflow was measured using nasal pressure associated with the sum of oral and nasal thermistor signals. Respiratory effort was monitored with abdominal and thoracic bands. An apnea was defined as a complete cessation of airflow ≥ 10 s and a hypopnea as a reduction ≥ 50% in the nasal pressure signal or a decrease between 30% and 50% associated with either oxygen desaturation ≥ 4% or EEG arousal. Apneas were classified as obstructive, central, or mixed according to the presence or the absence of respiratory effort.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Smartphone + application providing self-monitoring and self-care messages
Type intervention	Usual follow-up care (see 'control condition') plus: Patients received smartphone with an application designed to transmit clinical information. Patients transmitted self-measured morning and evening blood pressure (3-day measurements), CPAP adherence, and subjective sleepiness weekly through a questionnaire-based application. Quality of life questionnaires were transmitted monthly. Patients received daily pictograms with diet and physical-activity related messages on their smartphones.
Duration & frequency	Daily self-monitoring and self-care messages for period of 4 months
Control condition	Usual follow-up care: Patients were contacted after 2 days to ask about adherence, side effects, and any problems encountered with the machine. After 4 weeks of treatment, patients met with their sleep specialist and adherence data was transferred from their machines. After 4 months, data were transferred again and patients saw their sleep specialist and were re-evaluated.
Outcome(s)	
Assessment adherence	Data was downloaded from CPAP machines
Operationalization adherence	Mean nightly CPAP use in minutes

Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	4-Month results: Non-sign. (p-value not reported): 250 ± 166 VS 187 ± 178
Other	
Source of funding and competing interest	This study was supported by a grant from Initiatives pour la Santé Domicile. Funders of the trial had no role in study design, data collection, data analysis or writing of the report.
Study limitations and other comments	Adherence was secondary outcome measure and study was not adequately powered for secondary outcome measures. it is possible that telemedicine was perceived as an additional burden associated with the self-management of blood pressure and CPAP by patients randomized to this group. In fact, there were more dropouts in the telemedicine group than standard care (n = 8, 14.8% vs n = 1, 1.9%, respectively)

Study reference #11	
Authors	Nilius et al.
Year of publication	2012
Country	Germany
Study design	
Study conditions (*N*)	- UC (n=42, analyses conducted on subsample n=36) - UC + Intensive education (n=42, analyses conducted on subsample n=40)
Measurements	- Baseline - 3 Months
Study population	
Age (*M, SD*)	- 55.1 ± 12.0 - 49.8 ± 12.1
Gender (% female)	- 36.1 - 40.0
Target population and recruitment strategy	Adults with OSAS starting CPAP treatment, recruited through sleep laboratory program as part of a multi-level diagnostic investigation (medical history of increased daytime sleepiness and an RDI > 5 on a non-attended polygraph test).
Eligibility criteria	*Inclusion criteria:* - Adults with OSAS undergoing CPAP for the first time *Exclusion criteria:* - AHI > 20% of the events - Previous operations of pharyngeal structures - Apparent heart failure and malignant cardiac arrhythmia - Insufficient knowledge of the German language
Diagnostic procedure / OSA definition	Overnight attended PSG, which was evaluated by an experienced physician. The sleep stages and arousals were categorized in accordance with criteria of Rechtschaffen and Kales and recommendations of the American Sleep Disorders Association. Arousals were classified as respiratory if they occurred at the beginning of, or within 2 s, of apnea or hypopnea. If the flow signal was reduced by more than 50 % vis-à-vis in comparison with the initial signal, for more than 10 s, the episode was classified as hypopnea; if the amplitude of the flow signal was less than 20 % of the initial value, the episode was classified as apnea.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual education/follow-up care (see 'control condition') plus: Phone call by a specially trained non-medical employee once a week, with a planned total of 12 phone contacts. Any problems that had arisen were discussed. After 6 weeks, invitation to attend follow-up appointment at the clinic, which included a group briefing by a doctor, an individual consultation with a doctor, and a troubleshooting session regarding masks and devices by a trained technician. The data saved on the devices were read and the symptoms experienced during the day were assessed in accordance with the Epworth Sleepiness Scale.
Duration & frequency	Weekly telephone consultation over period of 3 months, 6-week clinic visit (i.e. training session)
Control condition	Usual education/follow-up care included instruction to consult GP or sleep laboratory in case of problems. After 12 weeks, an overall summary of CPAP use was made.
Outcome(s)	
Assessment adherence	Reading off data from CPAP device. Recording platform Alice (Respironics).
Operationalization adherence	1) Mean nightly CPAP use in hours 2) Mean nightly CPAP use in hours when considering only the patients using CPAP for >1 hour per night
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Non-sign. (p-value not reported): 3.8 ± 3.0 VS 3.7 ± 2.2 2) Non-sign. (p-value not reported): 4.6 ± 2.7 VS 4.3 ± 1.8
Other	
Source of funding and competing interest	-
Study limitations and other comments	Authors mention strict exclusion criteria as limitation: maybe a more problematic group of patients, e.g. those with cardiovascular diseases, would have the highest benefit of a more intensive training program.

Study reference #12	
Authors	Pengo et al.
Year of publication	2018
Country	United Kingdom
Study design	
Study conditions (*N*)	- UC (n=36, 2- and 6-week analyses conducted on subsample n=31 and n=25 respectively) - UC + Positively framed messages (n=36, 2- and 6-week analyses conducted on subsample n=32 and n=31 respectively) - UC + Negatively framed messages (n=37, 2- and 6-week analyses conducted on subsample n=31 and n=29 respectively)
Measurements	- Baseline - 2 Weeks - 6 Weeks
Study population	
Age (*M, SD*)	- 53.5 ± 12.5 - 46.7 ± 12.2 - 47.1 ± 11.7
Gender (% female)	- 20.5 - 30.6 - 24.3
Target population and recruitment strategy	Adults with OSAS starting CPAP treatment, recruited through sleep disorders centers at 2 hospitals.
Eligibility criteria	*Inclusion criteria:* - Patients diagnosed with OSAS starting CPAP therapy *Exclusion criteria:* - Mental or physical disability precluding compliance with the protocol
Diagnostic procedure / OSA definition	Prospective screening using nocturnal pulse oximetry (Pulsox 300i, Konica Minolta Sensing Inc.,Tokyo, Japan) for two consecutive nights at home. Both a 4% oxygen desaturation index (4% ODI) ≥5 hour and typical symptoms of sleep apnea (Epworth Sleepiness Scale >10), or a 4% ODI greater than 15 hour were invited for CPAP
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual care and follow-up care (see 'control condition') plus: Standardized motivational messages (either positively or negatively framed) were read out to patients during APAP collection appointment and through weekly telephone calls. Messages during appointment were read without adding any evaluative comments and without interruption. Calls lasted for 2-3 minutes and were non-interactive. The same messages were repeated once during weekly phone calls. Any other questions by the patients during these phone calls were directed to the clinical team (sleep specialists or qualified technicians) who phoned the patient back to address any clinical concerns.
Duration & frequency	Motivational messages were read during clinic visit and weekly through telephone calls (+- 2 a 3 minutes) over period of 6 weeks
Control condition	Usual care and follow-up care: Usual care consisted of 2 weeks APAP, 4 weeks CPAP. First, APAP collection session during which expert sleep technicians explained the importance of treating OSA and introduced APAP. Usual follow-up care furthermore included instructions on the use of their devices and one-to-one sessions were offered for patients experiencing difficulties. After 2 weeks, all patients were reviewed for troubleshooting and compliance assessment, and to exchange APAP for CPAP device.
Outcome(s)	
Assessment adherence	Automated data recorder in APAP device (S8/S9, ResMed Ltd, Sydney, Australia). Data was downloaded from SD cards.

Operationalization adherence	2-week follow-up: 1) APAP use for >4 hours (% days) 2) APAP use for >4 hours (days) 3) APAP use for <4 hours (days) 4) APAP not used (days) 5) APAP average daily usage (hours) 6) APAP total hours used 6-week follow-up: 1) CPAP use for >4 hours (% days) 2) CPAP use for >4 hours (days) 3) CPAP use for <4 hours (days) 4) CPAP not used (days) 5) CPAP average daily usage (hours) 6) CPAP total hours used
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	2-Week follow-up: 1) Non-sign. (p=.06) 2) Non-sign. (p=.08) 3) Non-sign. (p=.99) 4) Non-sign. (p=.08) 5) Non-sign. (p=.10) 6) Sign. (p<.05): 40.8 ± 33.5 VS 53.7 ± 31.4 VS 35.6 ± 27.4 6-Week follow-up: 1) Non-sign. (p=.88): 50.1 ± 34.2 VS 45.7 ± 30.5 VS 46.1 ± 32.5 2) Non-sign. (p=.68): 21.1 ± 16.3 VS 19.2 ± 16.9 VS 19.7 ±17.7 3) Non-sign. (p=.39): 9.7 ± 8.9 VS 13.1 ± 9.0 VS 12.0 ± 9.0 4) Non-sign. (p=.88): 10.4 ± 12.0 VS 8.2 ± 8.4 VS 9.2 ±11.6 5) Non-sign. (p=.62): 3.1 ± 2.7 VS 3.5 ± 2.7 VS 2.6 ± 2.2 6) Non-sign. (p=.68): 132.8 ± 113.8 VS 1.9 ± 112.9 VS 118.5 ±97.4
Other	
Source of funding and competing interest	The research was supported by the National Institute for Health Research (NIHR) Biomedical Research Center based at Guy's and St. Thomas' NHS Foundation Trust and King's College London.
Study limitations and other comments	Missing 6-week data due to loss to follow-up, meaning that adherence data about the difference between groups should be interpreted with caution.

Study reference #13	
Authors	Sedkouaki et al.
Year of publication	2015
Country	France
Study design	
Study conditions (*N*)	- UC (n=190) - UC + Telephone coaching (n=189)
Measurements	- Baseline - 4 Months
Study population	
Age (*M, SD*)	- 60.8 ± 12.6 - 58.9 ± 13.7
Gender (% female)	- 30.5 - 25.4
Target population and recruitment strategy	Adults with SAHS starting CPAP treatment, recruited through multiple sites. *Note: type of sites not specified*
Eligibility criteria	*Inclusion criteria:* - Patients for clinical PSG evaluation who were subsequently diagnosed with SAHS and prescribed CPAP. - Ability to understand and speak fluent French - Able to complete the study questionnaires *Exclusion criteria:* - Aged <18 years - Under guardianship - Previous use of CPAP - Psychiatric illness - Participation in another clinical trial
Diagnostic procedure / OSA definition	Clinical PSG evaluation. Daytime sleepiness and > 3 of the following criteria: snoring, morning headaches, reduced attention, nocturia, AHT, decreased libido, associated with AHI ≥ 30/h. If AHI was below 30/h a PSG was performed and >10 arousals/h were required.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telephone
Type intervention	Usual follow-up care (see 'control condition') plus: Five educational telephone coaching sessions (day 3, 10, 30, 60, 90 with equipment at home) by competent staff. First session: assess patient's knowledge about the disease, device and health consequences, and stress the importance of good adherence. Other educational telephone sessions focused on identifying disadvantages or obstacles to follow CPAP treatment, focusing on benefits linked to CPAP use, discussion of misconceptions about sleep apnea and barriers to use, concerns fears and beliefs, as well as the perceptions of their partners and family, in order to increase patients' positive expectations regarding CPAP benefits. Any problems in links with SAHS encountered by the patient to the technician, psychologist or dietician (employed by the home care provider) were discussed.
Duration & frequency	5 phone calls of approximately 15-20 minutes over period of 3 months
Control condition	Usual follow-up care: home visit during first week of CPAP by technician delivering and re-explaining CPAP device and treatment. Further 1-month home follow-up visit by home care provider to check mask tolerance and functioning of machine, as well as 4-month visit to assess CPAP parameters. Sleep physician checked the compliance (patient questioning and machine data) and efficiency of CPAP treatment in month 1, 3, and 6. Finally, medical follow-up once a year.
Outcome(s)	
Assessment adherence	CPAP data registered by machine.
Operationalization adherence	1) Primary outcome: % patients using CPAP for more than 3 hours per night for 4 months 2) Secondary outcome: mean nightly CPAP use in hours
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Sign. (p-value not reported): 65.0 VS 75.0 2) Sign. (p=.04): 4.08+/−2.25 VS 4.34 +/− 2.17

Other	
Source of funding and competing interest	Three authors have reported the following conflicts of interest: Nicole ROSSIN is employed by Sadir assistance, the home care provider. Ludivine LESEUX is employed by Sadir association. Mr. Jean-Louis FRAYSSE is the director of SADIR assistance. This study was funded by SADIR (home care provider).
Study limitations and other comments	Not all patients with coaching received the 5 phone calls as prescribed in the procedure due to business activity, holidays or patient requests to stop the phone calls. This might have biased results as a sign. and gradual link between patient phone calls received and mean hours of CPAP use was found.

Study reference #14	
Authors	Turino et al.
Year of publication	2017
Country	Spain
Study design	
Study conditions (*N*)	- UC (n=48) - UC + Telemedicine care (n=52)
Measurements	- Baseline - 1 Month - 3 Months
Study population	
Age (*M, SD*)	- 54 ± 12 - 56 ± 13
Gender (% female)	- 22.9 - 23.1
Target population and recruitment strategy	Adults with OSA requiring CPAP treatment, recruited through sleep unit of university hospital.
Eligibility criteria	*Inclusion criteria:* - Aged >18 years - Newly diagnosed OSA - Requiring treatment with CPAP (AHI >15 events/h) *Exclusion criteria:* - Impaired lung function (overlap syndrome, obesity hypoventilation and restrictive disorders) - Severe heart failure - Psychiatric disorders - Periodic leg movements, - Pregnancy - Other dysomnias or parasomnias - History of previous CPAP treatment
Diagnostic procedure / OSA definition	AHI >15 events/h.
Interventions	
E-health condition	
Add-on or replacement[1]	Add-on
Type technology	Telemonitoring, telephone
Type intervention	Usual follow-up care (see 'control condition') plus: Telemonitoring program collecting daily information about CPAP compliance, air leaks and residual respiratory events. Automatic alarms for the provider were generated in case of mask leaks (i.e. >30 L·min for >30% of the night) or usage of <4 hours a night on 2 consecutive nights. In case of alarm, the pulmonary specialist medical officer of the CPAP provider contacted the patient, providing case-by-case problem solving. This included suggestions about how to minimize symptoms (dry mouth, mask issues, discomfort with the device), specific interventions to improve compliance (mask changing, chin strap, pressure or humidifier settings, saline nasal sprays) and support for the patient in the use of CPAP.
Duration & frequency	Daily telemonitoring and telephone calls as needed (see 'type intervention') over period of 3 months.
Control condition	Usual follow-up care: clinic visit after 1 month of CPAP treatment by the specialist nurse at the sleep unit for data gathering purposes.
Outcome(s)	
Assessment adherence	CPAP device (AirSense 10; ResMed, Martinsried, Germany) was equipped with mobile 2G (GSM/ GPRS) technology capable of sending daily information on CPAP adherence to a web database (i.e. MyOSA– Oxigen Salud; www.oxigensalud.com).
Operationalization adherence	Average nightly CPAP use in hours.
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1-Month results: Non-sign. (p=.71): 5.2 ± 2.1 VS 4.8 ± 2.3 3-Month results: Non-sign. (p=.63): 4.9 ± 2.2 VS 5.1 ± 2.1

Other	
Source of funding and competing interest	-
Study limitations and other comments	The high level of compliance in the standard management group could have masked any potential benefits of telemonitoring.

Study reference #15	
Authors	Fields et al.
Year of publication	2016
Country	Pennsylvania & New Jersey, US
Study design	
Study conditions (*N*)	- Traditional in-person care (n=28, analyses conducted on subsample n=20) - Telemedicine care (n=32, analyses conducted on subsample n=14)
Measurements	- Baseline - 3 Months
Study population	
Age (*M, SD*)	- 58.2 ± 14.4 - 46.7 ± 13.1 *
Gender (% female)	6.0
Target population and recruitment strategy	Adult veterans with OSAS starting +H17:I19APAP treatment, recruited through community-based outpatient centers.
Eligibility criteria	*Inclusion criteria:* - Aged ≥ 18 years - Received primary care at community-based outpatient center - Fluent in English - Diagnosis of OSA (AHI ≥ 5 events/h) *Exclusion criteria:* - Inability to return for follow-up sessions - Previous diagnosis of sleep disordered breathing (OSA, central sleep apnea, Cheyne-Stokes respiration, obesity hypoventilation syndrome) or narcolepsy.
Diagnostic procedure / OSA definition	AHI ≥ 15 events per hour or 5 ≤ AHI 5-15 events per hour determined by an overnight home sleep test, with clinical symptoms.
Interventions	
E-health condition	
Add-on or replacement[1]	Replacement
Type technology	Video conferencing, DVD, telephone
Type intervention	Visits and phone calls in according to standardized patient encounter template (i.e. similar to traditional in-person care). Initial clinical video tele-health visit, instructional DVD for home sleep testing, and 3 phone calls after starting APAP treatment: after 1 week (check start APAP treatment, encouragement, answer questions), as well as after 1 and 3 months (APAP unit data review, assessment of PAP-related concerns (e.g. mask leaks, claustrophobia), reinforcement, and opportunity for patients' questions.
Duration & frequency	Clinical-video tele-health visit of 40 minutes (at baseline), 1-week phone call of 10 minutes, 1- and 3-month phone calls of ≤20 minutes
Control condition	Visits and phone calls in according to standardized patient encounter template (i.e. similar to telemedicine care). Initial clinical in-person visit providing information about OSAS and CPAP treatment, 1-2 week return visit with instructions for home sleep testing unit for use that same night (i.e. no DVD), 1 phone call after starting APAP treatment (same brief encounter as the telemedicine arm), and in-person follow-up visits after 1 and 3 months.
Outcome(s)	
Assessment adherence	Wireless modem technology was used to transfer APAP adherence data from APAP units (Respironics System One, Murrysville, PA) to EncoreAnywhere (Philips-Respironics), the latter being a HIPAA-compliant, password-protected internet database.
Operationalization adherence	1) Average nightly APAP use in minutes 2) Average nightly APAP use in minutes on nights being used 3) % nights with device usage 4) % nights using device ≥ 4 hours
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Non-sign. (p=.30): 175.6 ± 36.8 VS 220.8 ± 37.5 2) Non-sign. (p=.43): 268.9 ± 32.1 VS 305.7 ± 29.9 3) Non-sign. (p=.49): 54 ± 8 VS 65 ± 8 4) Non-sign. (p=.49): 39 ± 8 VS 47 ± 9
Other	
Source of funding and competing interest	Financial support was provided by VISN 4 Competitive Pilot Project Fund.
Study limitations and other comments	Baseline difference in age. Relatively small sample size. Logistical considerations forced a lack of provider-site homogeneity: providers could not visit both recruitment sites or participate in both study arms.

Study reference #16	
Authors	Isetta et al.
Year of publication	2015
Country	Spain
Study design	
Study conditions (*N*)	- UC (n=70) - Telemedicine-based CPAP follow-up (n=69)
Measurements	- Baseline - 1 Month - 3 Months - 6 Months
Study population	
Age (*M, SD*)	- 49.0 ± 10.1 - 51.0 ± 8.9 *Note: Sign. difference, p-value not reported on*
Gender (% female)	14.0
Target population and recruitment strategy	Adults with OSA who were requiring CPAP treatment, recruited through 8 hospitals in Spain.
Eligibility criteria	*Inclusion criteria:* - Diagnosis of OSA - Requiring CPAP treatment - Internet-connected device with a microphone and webcam *Exclusion criteria:* - Severe sleepiness - Severe nasal obstruction - Pregnancy - Psychiatric disease - Dangerous employment - Clinical instability - Current or previous treatment for OSA - Lack of sufficient internet skills
Diagnostic procedure / OSA definition	Overnight sleep study which was scored by trained personnel, showing AHI / Respiratory Disturbance Index (RDI) ≥ 30. Or, AHI / RDI ≥ 5 and <30 plus symptoms related with sleep apnea-hypopnea syndrome and/or an Epworth Sleepiness Scale score ≥ 12 and/or associated comorbidity.
Interventions	
E-health condition	
Add-on or replacement[1]	Replacement
Type technology	Video-conferencing and web-based portal with education, self-monitoring and messaging tool.
Type intervention	CPAP follow-up care at distance: 1) video-conference follow-up visits (month 1 and 3) 2) extra tele-visits or telephone calls if needed 3) website with information about OSA and CPAP therapy, and a biweekly 6-item questionnaire about their status, physical activity, sleep time, CPAP use and treatment side effects. Staff monitored questionnaire answers and communicated with patients through the website messaging tool to solve treatment-related problems. *Note: Unclear whether low CPAP adherence fell under the above-mentioned 'treatment-related problems'*
Duration & frequency	Two follow-up video-conference visits (month 1 and 3), and extra tele-visits or hospitals visits as needed.
Control condition	Standard face-to-face follow-up care: hospital follow-up visits (month 1, 3, and 6), and extra visits or telephone calls if needed.
Outcome(s)	
Assessment adherence	n/a
Operationalization adherence	1) Mean nightly CPAP use in hours 2) % adherers, defined as CPAP use >4 hours a night
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	6-Months results: 1) Non-sign. (p=.83): 4.2 ± 0.3 VS 4.4 ± 0.3 2) Non-sign. (p=.33): 57% VS 65%

Other	
Source of funding and competing interest	This project was supported by SEPAR/FIS PI14/00416 and ECO2013-47092 (MINECO, Spain)
Study limitations and other comments	Noteworthy: approximately 40% of screened patients lacked sufficient computer expertise/skills.

Study reference #17	
Authors	Stepnowsky et al.
Year of publication	2007
Country	California, United States
Study design	
Study conditions (*N*)	- UC (n=21, analyses conducted on subsample n=20) - Telemonitored care (n=24, analyses conducted on subsample n=20)
Measurements	- Baseline - 2 Months
Study population	
Age (*M, SD*)	59 ± 14.3
Gender (% female)	0.2
Target population and recruitment strategy	Adults with OSA starting CPAP treatment, recruited through referrals of physicians to sleep clinic by means of veterans affairs healthcare system.
Eligibility criteria	*Inclusion criteria:* - Diagnosis of moderate-to-severe OSA (AHI ≥ 15 events per hour) - Naive to CPAP therapy - Stable sleep environment (operationally defined as a permanent address, requisite for wireless monitoring) - Aged ≥ 18 years *Exclusion criteria:* - Allergies or sensitivity to the mask or mask material - Previous use of any other PAP device (e.g., bi-level PAP, auto-adjusting PAP) - Current use of prescribed supplemental oxygen - Significant comorbid medical conditions that would prevent the patient from completing the protocol (i.e. any medical or mental health condition that could interfere with the daily use of CPAP) - When living in geographically unsuitable region (i.e., outside of the wireless network coverage area).
Diagnostic procedure / OSA definition	Sleep study demonstrating AHI ≥ 15 events/h.
Interventions	
E-health condition	
Add-on or replacement[1]	Replacement
Type technology	Telemonitoring
Type intervention	Daily telemonitoring (2-months) of compliance and efficacy data (mask leaks, AHI) and acting on those data collaboratively, and in partnership, with the patient. Collaborative management refers to the joint decision making and partnership between provider and patient and is characterized by communication, negotiation, and consideration of important patient factors and preferences. The frequency and nature of the clinical interactions depended on both the objectively measured nightly data values and subjective patient reports. Thresholds for the compliance and efficacy data: CPAP compliance (i.e. 4 hours a night), AHI (i.e. 10 events/hours of sleep), and mask leak (0.4 L/s).
Duration & frequency	Daily telemonitoring and corresponding collaborative management over 2 months
Control condition	Usual follow-up care: 1-week telephone call after CPAP initiation and a 1-month in-office follow-up visit by CPAP clinic staff. Patients were encouraged to call the clinic any time they had a problem or concern. CPAP compliance and efficacy data were downloaded at the 1-month time point to help direct clinical management.
Outcome(s)	
Assessment adherence	Device-internal clock counter. CPAP device (AutoSet Spirit flow generator unit, ResMed Corp, Poway, CA) with attached ResTraxx wireless transmitter (ResMed Corp, Poway, CA). De-identified data were transmitted to a computer server. Research and clinical staff had secured access to data via standard browser and entry into the ResTraxx Data Center, the management website designed for 24/7 access to telemonitored data.
Operationalization adherence	1) Mean nightly CPAP use in hours on all days 2) Mean nightly CPAP use in hours on nights being used 3) % nights in which CPAP was used >0 hours 4) % nights in which CPAP was used >4 hours
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Non-sign. (p=.07): 2.8 ± 2.2 VS 4.1 ± 1.8 2) Non-sign. (p=.10): 3.8 ± 2.3 VS 5.0 ± 1.8 3) Non-sign. (p=.07): 60 ± 32 VS 78 ± 22 4) Non-sign. (p=.16): 37 ± 34 VS 52 ± 27

Other	
Source of funding and competing interest	The study was supported in part by the VA San Diego Healthcare System, and the Veterans Medical Research Foundation.
Study limitations and other comments	Limited sample size to detect effects due to underestimated residual variance. The study design dictated that both groups have ResTraxx wireless devices attached to their flow generator units. Given possible placebo effects, the UC group did not necessarily receive usual and customary care because of the presence of the wireless unit. Hence, this study may have underestimated the effect of telemonitoring on CPAP compliance.

Study reference #18	
Authors	Stepnowsky et al.
Year of publication	2013
Country	California, United States
Study design	
Study conditions (*N*)	- UC (n=115) - 'MyCPAP': Internet-based intervention based on wireless telemonitoring care (n=126) *Note: 7 participants withdrew, but unclear from which study condition and how missing data were dealt with.*
Measurements	- Baseline - 2 Months - 4 Months
Study population	
Age (*M, SD*)	52.1 ± 13.3
Gender (% female)	n/a
Target population and recruitment strategy	Adults with OSA starting CPAP treatment, recruited through sleep medicine center of a university.
Eligibility criteria	*Inclusion criteria:* - Diagnosis of OSA (AHI ≥ 15) - CPAP therapy prescription - Aged ≥ 18 years *Exclusion criteria:* - Residence in a geographical area outside of San Diego County (which could make regular contact and participation difficult) - Fatal comorbidity (life expectancy < 6 months as indicated by treating physician) - Significant documented substance/chemical abuse.
Diagnostic procedure / OSA definition	AHI ≥ 15 events/h as measured by an overnight sleep study.
Interventions	
E-health condition	
Add-on or replacement[1]	Replacement
Type technology	Telemonitoring, web-based portal for education and self-monitoring
Type intervention	MyCPAP was comprised of as-needed clinical contacts, based on objectively measured CPAP adherence and efficacy data and access to a patient-oriented website. MyCPAP Website had the following main goals: (a) allow both the patient and provider access to telemonitored adherence and efficacy data on a daily basis (b) act on that data collaboratively to guide CPAP management and troubleshoot problems early and effectively, and (c) emphasize ways for the patient to express their preferences and needs. The website included 1) Education section providing basic education about sleep apnea, CPAP, and collaborative management 2) CPAP data section including easy-to-read charts that show CPAP adherence (in hours a night) and CPAP efficacy data (disease severity as measured by number of apneas and hypopneas per hour) and amount of air leak (in liters/min). 3) Graph section including both easy-to-complete individual items for patients to track, including sleepiness levels and other patient-selected OSA-related symptoms. 4) Troubleshooting guide: interactive guide that allowed patients to select the CPAP problem they were having, and possible causes and solutions were listed accordingly. 5) CPAP user's manual including animations.
Duration & frequency	CPAP telemonitoring every day throughout the active 2-month treatment period.
Control condition	Usual follow-up care: clinical contacts at predetermined times (1 week, 1 month) by CPAP clinic staff. Also, patients were encouraged to call whenever they had a problem or concern. Adjustments or changes in the mask interface as well as pressure level changes were conducted if warranted. If the patient brought in their CPAP unit, the data was downloaded and utilized.
Outcome(s)	
Assessment adherence	UC participants: digital data smart card in CPAP device (PAP Autoset II, ResMed,San Diego,CA) recorded the amount of time the machine was used therapeutically. Data were downloaded from the smart card. MyCPAP participants: wireless modem attached to PAP device, which could send data from device to Web-portal accessible by our team. The web-portal ("Restraxx Data Center," or RDC), is comprised of the wireless module and the server/ database, which houses the data and restricts access to authorized health care professionals.
Operationalization adherence	Mean nightly CPAP use in hours.

Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	2-Month results: Sign. (p=.02): 3.4 ± 2.4 VS 4.1 ± 2.3 4-Month results: Sign. (p=.03): 3.2 ± 2.4 VS 3.9 ± 2.3
Other	
Source of funding and competing interest	This research was primarily supported by the AHRQ 1R18HS017426-01 and in part by the VA San Diego Research Service and Veteran's Medical Research Foundation.
Study limitations and other comments	-
Study reference #19	
Authors	Taylor et al.
Year of publication	2006
Country	Washington, United States
Study design	
Study conditions (*N*)	- UC (n=58, analyses conducted on subsample n=49) - Telemedicine care (n=56, analyses conducted on subsample n=47) Note: analyses presumably conducted on subsample; method handling missing data unclear
Measurements	- Baseline - 1 Month
Study population	
Age (*M, SD*)	- 44.6 ± 8.5 - 45.8 ± 10
Gender (% female)	- 29.0 - 34.0
Target population and recruitment strategy	Adults with OSAS starting CPAP treatment, recruited through university-affiliated sleep disorders center.
Eligibility criteria	*Inclusion criteria:* - Patients diagnosed with OSAS starting CPAP therapy *Exclusion criteria:* - Current or previous treatment with nasal CPAP or other therapies such as an oral appliance or surgery for OSAS
Diagnostic procedure / OSA definition	A respiratory disturbance index (RDI) > 4 accompanied by symptoms of excessive daytime sleepiness. OSAS severity was determined by RDI events per hour: 5–14=mild, 15-29=moderate, and ≥30= severe.
Interventions	
E-health condition	
Add-on or replacement[1]	Replacement
Type technology	Tele-self-monitoring, automated computer-based support and feedback, telephone
Type intervention	Daily telemonitoring through self-report as provided via a home computer called the "Health Buddy". The Health Buddy OSAS Library was customized with information and suggested interventions. The library comprised preprogrammed questions and answers in a patient–provider dialogue covering four general aspects of OSAS care: symptom management, health behavior, knowledge, and general questions. Patient–provider dialogues were designed to provide education in the pathophysiology of OSAS, reinforce knowledge regarding nasal CPAP use, encourage skills mastery techniques and self-management behaviors, and interpret nasal CPAP symptoms and common side effects. High-risk patients (<4 hours of CPAP use during sleep for >3 days) were contacted by telephone by the sleep medicine practitioner within 24 hours.
Duration & frequency	Daily self-monitoring and computer-based support and feedback, telephone calls in case of high risk of compliance only
Control condition	Usual follow-up care: Clinic visit 1 month after starting CPAP and any subsequent clinic visits felt necessary by the care provider. Also, participants were able to access the sleep medicine practitioner for telephone consultations and walk-in visits.
Outcome(s)	
Assessment adherence	Automated data recorder in the CPAP device
Operationalization adherence	1) Average nightly CPAP use in hours over 30-day observation period 2) % nights CPAP use of ≥ 4 hours on all of the nights monitored over 30-day observation period
Results	
Effects (*M, SD*) on adherence, incl. significance (*p*-values)	1) Non-sign. (p=.87): 4.22 ± 2.05 VS 4.29 ± 2.15 2) Non-sign. (p=.61): 50.1 ± 33.8 VS 46.9 ± 34.2"

Other	
Source of funding and competing interest	Supported by the Telemedicine Directorate, Walter Reed Army Medical Center, Washington, DC.
Study limitations and other comments	A confounding factor that may have blunted a difference between the randomized groups was the similar availability of follow-up care to each group. Such follow-up care included telephone contact and walk-in access to care. The increased number of telephonic contacts to the telemedicine group was balanced by walk-in care accessed by the traditional care group. Within the telemedicine group, 7 of the 9 participant who withdrew during study, did so because of failure to activate the Health Buddy computer.

UC = Usual care; CG = Control group; OSA = obstructive sleep apnea; OSAS = obstructive sleep apnea syndrome; OSAHS = Obstructive Sleep Apnea Hypopnea Syndrome; SAHS = Sleep Apnea/Hypopnea Syndrome; CPAP=Continuous positive airway pressure; APAP=Automatically-Adjusting Positive Airway Pressure; PAP: Positive Airway Pressure; AHI = Apnea/Hypopnea Index; Sign. = Significant; PSG = polysomnography

[1] Indicates whether the E-health intervention was an add-on, or replacement of usual (follow-up) care as provided during treatment of CPAP in the control condition.
* $p < .05$