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Early View

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Telemedicine home CPAP titration and follow-up in the COVID-19 scenario

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Telemedicine home CPAP titration and follow-up in the COVID-19 scenario

Take Home Message: Telemedicine home CPAP titration and early follow-up is equivalent to usual care in adaption and compliance while achieving greater patient satisfaction. The use of a mHealth app may help patients self-empower and encourage increased CPAP use.

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INTRODUCTION

Obstructive sleep apnea (OSA) is a highly prevalent chronic disease associated with important comorbidities such as traffic accidents, cardiovascular and metabolic diseases and mortality, among others (1). Continuous positive airway pressure (CPAP), a first-line therapy in moderate-severe OSA (2), has been proven successful in improving daytime sleepiness, quality of life, reducing traffic accidents (3), improving hypertension and paroxistical atrial fibrillation (4,5). However, 47% of successfully titrated patients abandon treatment within three years (5,6). Thus, early OSA and CPAP education with close follow-up is mandatory to achieve satisfactory CPAP compliance (6,7). In that context, telemedicine and telemonitoring through remote monitoring CPAP have become promising strategies (8,9). Recently, smartphone applications (10) and wearables (11) have been added as new suggested tools for improving CPAP compliance.

The onset of the coronavirus disease 2019 (COVID-19) pandemic (12) saw a reduction in sleep unit activity of almost 80% in the two first months (13). As SARS-COV-2 remains viable in aerosols for three hours (14), CPAP titration is a challenging procedure as it generates droplet dispersion and involves a noteworthy increase of the biological risk for both medical staff and patients. Hence, home strategies for respiratory therapies with the implementation of telemedicine were encouraged by medical societies to diminish the risk of COVID-19 infection (15,16). Previous studies, have shown satisfactory results in CPAP home titration (17) and CPAP follow-up by telemedicine (18). The feasibility of smartphone applications, as well as the so-called mHealth app (10,19,20), has also been demonstrated. Nevertheless, to our best knowledge, there is no study on CPAP titration by telemedicine in the new COVID-19 scenario comparing different telemedicine strategies including telemonitoring with and without a smartphone application for clinical CPAP follow-up.

Therefore, this study aims to compare telemedicine strategies for home CPAP titration initiated in the COVID-19 pandemic scenario with the previous standard CPAP home titration through hospital face-to-face visits.

METHODS

Study design

A prospective telemedicine cohort (TC) undergoing CPAP titration and follow-up initiated to restart titrations during the COVID-19 pandemic scenario was compared with a retrospective cohort (RC) with the usual CPAP home titration and follow-up. The TC included a subgroup using a smartphone application (TC-APP).

The main endpoints were successful CPAP adaptation and CPAP compliance at one month of follow-up. Secondary endpoints were reported patient satisfaction and the direct staff costs of the different telemedicine approaches.

This study was approved by the ethics committee at our tertiary care level hospital (PR271/20). The telemedicine prospective included patient signed informed consent, whereas for the retrospective patient oral informed consent was obtained via a telephone call and then registered in the clinical records.

Patients

Patients were consecutively recruited for both cohorts from February to May 2019 for RC and from September 2020 to February 2021 for TC.

Eligible patients were adults (≥ 18 years old) with a recent OSA diagnosis and CPAP treatment indication. Patients under CPAP treatment, or unstable acute or chronic diseases were excluded. A certain educational level or regular smartphone use was not required for inclusion. At baseline, all clinical, demographic and sleep variables were registered for the two cohorts.

Home CPAP titration strategies

The home-CPAP titration workflow in the RC was initiated by scheduling an in-person visit in the hospital by a sleep unit nurse, who provided educational information with additional written support, performed individual CPAP training for 45-60 minutes and selected an appropriate mask. Then, autoCPAP was delivered to the patient, who returned it the next day and after the data was downloaded, a fixed pressure was prescribed. The optimal pressure was determined visually on the raw data as the pressure that covered 90% of the period without leaks (17). The titration was considered unsuccessful when sleep time was subjectively under five hours or when significant leaks were observed during most of the night. The home titration procedure was repeated up to two additional times when the home CPAP titration circuit was considered unsuccessful. Those patients were excluded from further analysis in this study and in-laboratory full polysomnographic CPAP titration was performed. After a successful titration, the CPAP was supplied to patient by the healthcare provider, and the sleep unit nurse phone number was given to the patient to use in case of requiring assistance. Face-to-face follow-up at one month by a sleep unit nurse was performed assessing CPAP compliance and adverse effects. Patient satisfaction was obtained by phone specifically for the study at inclusion.

The two TC strategies implemented were: 1) Nurse call-visit informing about CPAP titration procedure. Information was also sent by both postal letter and email. Information included an educational YouTube video link regarding CPAP use and training. Additionally, the phone number of the sleep unit nurse was given to the patient in case of requiring assistance. The healthcare provider supplied autoCPAP (Dreamstation CPAP Pro, Respironics) for three nights (pressure range: 6-12 cmH2O), which was equipped with a modem for remote data transmission and titration. The sleep unit nurse telemonitored CPAP compliance, leaks, residual IAH and pressure through the EncoreAnywhere platform and a phone call or videoconference visit was performed if required. A CPAP fixed pressure was prescribed as described previously according to the three-night raw data (17). The healthcare provider supplied the CPAP device. Cases of unsuccessful home titration were referred to in-laboratory titration (and were also excluded from further analysis, as in the RC). A phone call or videoconference follow-up sleep unit nurse visit was performed at one month to assess adverse effects, patient satisfaction and objective CPAP adherence as registered by the home CPAP device used by the patient was obtained by the health care provider) The second telemedicine strategy also included recommending the use of a smartphone application (Estoi®), a download link and written information were sent by letter and email.

Estoi® is a smartphone application that provides: 1) educational information in text and video formats regarding CPAP use and frequent adverse effects or problems; 2) side effects, tolerance and compliance questionnaires with weekly reminder notifications; 3) an algorithm that recommends educational texts and videos based on the problems detected in the questionnaires; 4) telemonitoring of questionnaires by the medical team with an alarm system; and 5) open messaging system between the patient and medical team.

Statistics

Demographic, clinical, OSA treatment, and titration variables were analyzed according to the type of variable and are presented in tables according to the study group. The raw effect of the group on these variables was analyzed using logistic regression models. The model was replicated by adding variables such as age, sex, body mass index (BMI), educational level, and apnea to observe the adjusted effect. The raw effect of the group on these variables was analyzed using linear models according to the distribution of the variable. To observe the adjusted effect, the model was replicated by adding variables such as age, sex, BMI, educational level, and apnea. Staff direct cost were estimated using €32.76/hour for the specialized sleep nurse and €52.92 /hour for the sleep doctor.

RESULTS

210 consecutive patients were evaluated (80 RC and 130 TC). Nine were excluded in the RC and 13 in the TC (Figure 1). From 188 analyzed patients, 71 were RC and 117 were TC of which 44 patients were not offered the app, and 76 were offered the app, which was used by 36 patients (TC-APP).

Patients' characteristics are shown in Table 1. No significant baseline differences were detected between the retrospective and telemedicine cohorts, neither between those who used the app and those who did not. Sleep study and OSA characteristics are depicted in Table 2, no relevant differences were found between the RC and TC. Baseline IAH was higher in TC-app vs TC-noAPP (IAH 53.1/h versus 36.8/h respectively, p=0.022).

CPAP was successfully titrated and adapted in 90% of the RC, while for TC the corresponding figure was 94.9% and 100% in TC-APP. Despite the improvement in the TC, and especially in TC-APP, the differences did not reach statistical significance. However, successful single-time CPAP titration was significantly higher (p<0.001) in the TC (99%) than in the RC (78.9%). Attendance at the first follow-up visit was significantly higher in the TC than in the RC (100% vs 90%, p=0.0044).

No CPAP compliance differences were found between cohorts. When assessing the RC versus TC by multivariate logistic models, age was the only factor which increased by 5% the probability of one month CPAP compliance > four hours per night (Odds Ratio [OR] 1.05, Confidential Interval [CI] 1.02-1.09, p=0.002) (Table 3; A). Whereas in the two TC (with and without APP) multivariate logistic models, a high educational level increased the probability of one month CPAP compliance > 4hours per night by 294% (OR 3.94, CI 1.33-13.04, p-value 0.017) (Table 3; B).

Patient satisfaction (0-10) was significatively higher (p-<0.001) in the TC (9.02/10 (SD 0.64)) than in the RC (7.69/10 (2.05 SD)), and 68.9% of RC patients were satisfied vs. 98% TC, p-value <0.001 according to the survey of patients (Table 4). Patient satisfaction remained significatively higher in TC when adjusted for other important parameters (see Table 3,C). Patients in the TC reported easier access to healthcare staff compared to patients in the RC (100% vs. 59%, p-value <0.001). Thirty-six percent of the patients in the RC would prefer a new CPAP adaptation to be performed telematically, while 94% of the TC would have preferred a new telematic process (p-value <0.001). Finally, our telemedicine strategy would be recommended to others by 96% of the patients. Non-significant differences were detected in satisfaction between both telemedicine strategies. Nevertheless, 64% of the TC-APP reported that their telemedicine strategy influenced in increase in CPAP use compared to 45% in the TC-noAPP (p-value 0.011).

Regarding the patients in the TC-APP (Table 5), 66% responded to the app questionnaires, 61% used the messaging system, 73% of the messages were initiated by the patient and 27% by the medical team because of an alarm in the system. Nine messages sent via APP (43%) resulted in an action to improve CPAP adaptation. The compliance reported by the app was, on average, 6.36 hours per night (SD 1.21), which did not correlate with objective CPAP compliance hours (r 0.58).

CPAP adaptation with follow-up had an estimated staff direct cost per patient of €19.61 (SD 8.61) in TC-noAPP compared to €23.79 (SD 9.94) in TC-APP (p-value 0.0483).

DISCUSSION

To the best of our knowledge, this is the first CPAP titration and follow-up study performed entirely during the COVID-19 pandemic through two different telemedicine strategies which are compared with the face-to-face standard of care in place before the pandemic. Our main results showed that telemedicine is equivalent to the previous standard care in terms of successful titration and in CPAP compliance at one month of follow-up, as well as providing higher patient satisfaction. The additional use of the app can facilitate compliance in the patients' opinion, but no significant differences were demonstrated in this group.

The new COVID-19 scenario has presented unsuspected challenges and has advanced telemedicine implementation (13) responding to concerns of biological risk (14), especially in respiratory care units (15,16). The new strategies developed to maintain activity in the sleep units have been achievable as a result of previous experience in telemedicine (21–23), and, more than a temporary solution, they could represent an option to be considered in regular activity.

Our data showed that successful CPAP adaptation and titration increased in TC (95%), especially in TC-APP (100%), against RC (90%), without achieving statistical significance, probably due to the small sample size. This telemonitored titration protocol based on sleeping several nights at home with the autoCPAP device takes advantage of not requiring additional patient displacement, since adherence, air leakage and pressure are remotely managed, and daily sleep unit staff intervention can improve adaptation in consecutive days, increasing successful CPAP titration.

One month CPAP compliance and sleepiness measured by Epworth sleepiness score was similar in the RC and TC. Therefore, the telemedicine strategy used is as useful as face-to-face management, not only for achieving CPAP titrations, but also for achieving good compliance and clinical response at one-month of follow-up, which is a predictor of good long-term CPAP compliance (24). Likewise, in the multivariate analysis, neither RC nor TC, nor gender, basal AIH, BMI, or Epworth had an influence on compliance > 4h of CPAP/night. Only age was related to greater compliance. Therefore, this supports the idea of not limiting the use of titration by telemedicine in older patients.

Studies analyzing different telemedicine strategies for CPAP follow-up have found that CPAP compliance was equivalent to that with usual care (18,25–28). Only a few studies were successful in increasing CPAP compliance up to 30 min/night through phone coaching implementation (26 min/night) (29), or other methods .Nevertheless, a recent CPAP telemonitoring meta-analysis (22) did not find differences in CPAP compliance with telemonitored and standard CPAP follow-up. In our study, it is worth noting that a sleep unit telephone number was already available to patients in our standard care system previous to COVID-19, so there was no improvement in TC in terms of adaptation or during follow-up.

Only one other study carried out during the COVID-19 pandemic (30) has evaluated the telemedicine approach of CPAP titration compared with face-to-face titration. Similar to this study, equivalence in one month CPAP compliance was observed. Nevertheless, CPAP telemonitoring was performed throughout the entire study period (30), whereas in the present study, telemonitoring was only performed during the three days of CPAP titration. The equipment used after titration was chosen because of CPAP provider availabilities. Nevertheless, the present study demonstrated that telemonitoring titration plus standard CPAP after titration and telematic follow-up obtains equivalent results as in-person titration and contributes to building up new evidence supporting alternative telematic titration workflows.

Regarding perceived patient satisfaction, the TC reported greater satisfaction than RC. The patients probably perceived as a significant advantage avoiding displacement to the hospital during the pandemic. Moreover, one of the most promising reported telemedicine benefits was patient satisfaction, and especially when the mHealth app was incorporated. Using the “APPnea” smartphone application for CPAP self-monitoring Iseta el al (18), found that 83% of patients were very satisfied compared to 72% in the control group and 82% of patients would integrate as part of follow-up. The latest study (20) using “APPnea” for recovering patients with poor adherence to CPAP was reported useful by 60% of patients, while 82% would recommend the app to other patients and 85% would integrate it as part of follow-up. Similarly, our patient’s satisfaction was significantly greater in the TC with a mean value of 9.02/10 (0.64 SD) against RC 7.69/10 (2.05 SD) (p-value <0.001). In addition, only 6% of the patients in the TC reported that would prefer to perform it face-to-face. Interestingly, 36% of our RC would prefer to perform telematically, and 96% of TC recommend our telemedicine program to others. Patients in both telemedicine strategies reported easy access to healthcare professionals, felt confident about the security of their confidential data and would recommend the telemedicine strategy used to others. The loss of the human patient-doctor relationship is the greatest risk of

telemedicine use (21,23); however, these studies show the potential of bringing the patient closer to the doctor when the technology is used appropriately.

Unlike other sleep telemedicine studies which used mobile applications (20,31), in our methodological design, patients without technological skills were not excluded. Even though the percentage of patients who used the mobile application was not high (33/76), there were no differences in the educational level or age among those who used the app and those who did not. This fact contrasts with the well-known barriers to adopting telemedicine (32), such as resistance to change, cost, elderly age and educational level. The COVID-19 pandemic may have influenced in decreasing telemedicine barriers by reducing resistance to change from elderly people when technological use became essential for staying in contact with their relatives, avoiding social isolation and loneliness (33). Nevertheless, the influence of educational level on CPAP compliance observed in telemedicine multivariable models suggests that it is more important than telemedicine itself. Patients who used the application and asked questions about side effects had their questions answered before the one-month visit (43% of the questions generated an action to improve CPAP adaptation, mostly change of mask). Moreover, most patients in the TC-APP reported that telemedicine influenced in increasing CPAP use, though overall, no increase in compliance was found compared to TC-noAPP.

The other outstanding benefit of telemedicine is cost-efficiency. Previous studies demonstrated that telemedicine strategies for follow-up (without titration involvement) were cost-efficient: Isetta et al (18) reported a cost of €168.4 for web site follow-up in a telemedicine group compared to €180.4 for the control group, while Garmendia et al (20) estimated a cost of €103 per-protocol patient, reaching €152 for patients recovered in a rescue study of low CPAP compliance patients. We estimated only the direct medical staff time cost in the TC and the cost was only slightly higher in the TC-APP group. This cost is very small and could be cost-effective if better compliance is demonstrated in further studies.

This study has several limitations, beginning with a retrospective control group and an unrandomized design. Nevertheless, these factors could also be considered a strength since it allowed us to compare our TC findings with real-life retrospective usual care previous to the COVID-19 pandemic. Patient satisfaction questionnaires were obtained by phone which may constitute a bias per se as this method precludes anonymity. Furthermore, for the RC, they were completed after one year, which may have altered the results compared to the one-month evaluation. There was no bias in prospective or prospective cohorts, all consecutive patients were included, as no differences were found between groups. This ensures that the results are reproducible in routine clinical practice. Patient self-selection in the use of the mobile application would be another limitation. However, it is also an opportunity to evaluate two different telemedicine strategies including app use, in contrast with other telemedicine studies that excluded patients without technological abilities. Finally, the cost analysis only includes direct staff cost using the rates provided by the accounting department of a hospital in the Spanish public healthcare system, and therefore cannot be extrapolated in absolute terms to private centers or to other countries. However, the cost analysis does serve to illustrate the small relative difference between the two strategies.

CONCLUSIONS

Telemedicine for CPAP adaptation and titration and early follow-up are equivalent to usual care face-to-face visits in terms of successful CPAP titration and compliance, with greater patient satisfaction, and it can therefore be used independently of the COVID-19 pandemic. The use of the mHealth app could help patients to self-empower, as well as encouraging them to increase CPAP use. However, further studies are needed to confirm its value.

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Table 1. Patient characteristics

	Retrospective cohort (RC) vs Telemedicine cohort (TC)			TC: Smartphone application not used vs Used		
	RC	**TC**	**p.value**	**TC_noAPP**	**TC_APP**	**p.value**
	N=71	***N=117***		*N=81*	*N=36*	
Gender (Male), N (%):	48 (67.6%)	80 (68.4%)	1.000	57 (70.4%)	23 (63.9%)	0.631
Age, Mean (Standard Deviation)	57.8 (11.6)	59.5 (12.6)	0.338	60.6 (12.9)	57.1 (11.6)	0.142
Smoking exposure, N (%):			0.093			0.131
Never	25 (35.2%)	51 (43.6%)		34 (42.0%)	17 (47.2%)	
Smoker	17 (23.9%)	36 (30.8%)		22 (27.2%)	14 (38.9%)	
Former smoker	29 (40.8%)	30 (25.6%)		25 (30.9%)	5 (13.9%)	
BMI, Mean (Standard Deviation)	36.6 (9.63)	34.8 (7.21)	0.181	34.9 (7.05)	34.7 (7.66)	0.884
BMI categories, N (%):			0.250			0.239
Normal or healthy Weight	2 (2.82%)	7 (5.98%)		3 (3.70%)	4 (11.1%)	
Overweight	18 (25.4%)	19 (16.2%)		15 (18.5%)	4 (11.1%)	
Obese	51 (71.8%)	91 (77.8%)		63 (77.8%)	28 (77.8%)	
Arterial hypertension, N (%)	44 (62.0%)	67 (57.3%)	0.629	48 (59.3%)	19 (52.8%)	0.652
Diabetes mellitus, N (%)	16 (22.5%)	25 (21.4%)	0.995	18 (22.2%)	7 (19.4%)	0.925
Dyslipidemia, N (%)	32 (45.1%)	45 (38.5%)	0.459	32 (39.5%)	13 (36.1%)	0.887
Gastro-oesophageal reflux disease	4 (5.63%)	2 (1.71%)	0.201	1 (1.23%)	1 (2.78%)	0.523
Kidney disease	5 (7.04%)	4 (3.42%)	0.302	3 (3.70%)	1 (2.78%)	1.000
Heart disease, N (%)	18 (25.4%)	18 (15.4%)	0.136	13 (16.0%)	5 (13.9%)	0.983
Respiratory disease, N (%):			0.033			1.000
COPD	5 (7.04%)	10 (8.55%)		7 (8.64%)	3 (8.33%)	
Asthma	6 (8.45%)	2 (1.71%)		2 (2.47%)	0 (0.00%)	
Interstitial Lung Disease	2 (2.82%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Neurological disease, N (%)	6 (8.45%)	9 (7.69%)	1.000	8 (9.88%)	1 (2.78%)	0.271
Hypothyroidism	4 (5.63%)	3 (2.56%)	0.429	1 (1.23%)	2 (5.56%)	0.224
Migraine	0 (0.00%)	4 (3.42%)	0.299	3 (3.70%)	1 (2.78%)	1.000
Fibromyalgia	1 (1.41%)	3 (2.56%)	1.000	2 (2.47%)	1 (2.78%)	1.000
Depression/anxiety	7 (9.86%)	17 (14.5%)	0.481	14 (17.3%)	3 (8.33%)	0.325
Malignant disease history	5 (7.04%)	2 (1.71%)	0.106	2 (2.47%)	0 (0.00%)	1.000
Educational level, N (%):			0.175			0.465
Reading and writing difficulties OR No High School	40 (58.0%)	78 (69.0%)		56 (71.8%)	22 (62.9%)	
High School and Associated degree OR College and Graduate degree	29 (42.0%)	35 (31.0%)		22 (28.2%)	13 (37.1%)	

Table 2. OSA diagnosis, CPAP treatment and follow-up

	Retrospective cohort (RC) vs Telemedicine cohort (TC)			Telemedicine cohort: Smartphone application no used vs Used		
	RC	**TC**	**p.value**	**TC_noAPP**	**TC_APP**	**p.value**
	N=71	***N=117***		*N=81*	*N=36*	
OSA DIAGNOSIS						
Diagnosis OSA study test, N (%):			**0.040**			0.697
Nocturnal pulsioximetry	1 (1.41%)	8 (6.84%)		6 (7.41%)	2 (5.56%)	
Respiratory polygraphy	44 (62.0%)	83 (70.9%)		59 (72.8%)	24 (66.7%)	
Polysomnography	26 (36.6%)	26 (22.2%)		16 (19.8%)	10 (27.8%)	
						0.022
Apnea/hipoapnea index (events/h), Median [Q1; Q3]	46.0 [32.5;67.6]	40.8 [26.8;57.5]	0.134	36.8 [25.1;53.0]	53.1 [31.5;71.1]	
Apnea/hipoapnea supine index (events/h), Median [Q1; Q3]	57.5 [39.2;72.4]	53.6 [32.0;70.2]	0.157	47.3 [28.9;66.3]	58.5 [38.6;75.6]	0.146
TST90 (%), Mean (SD)	22.4 (26.1)	19.0 (22.1)	0.356	18.8 (22.1)	19.4 (22.4)	0.889
Sleepiness, N (%):			0.292			**0.019**
No	7 (9.86%)	23 (20.0%)		12 (14.8%)	11 (32.4%)	
Passive	46 (64.8%)	62 (53.9%)		50 (61.7%)	12 (35.3%)	
Active	13 (18.3%)	21 (18.3%)		15 (18.5%)	6 (17.6%)	
Driving	5 (7.04%)	9 (7.83%)		4 (4.94%)	5 (14.7%)	
Apnea, N (%):			**<0.001**			0.067
No	8 (11.3%)	6 (5.17%)		2 (2.47%)	4 (11.4%)	
Yes	50 (70.4%)	110 (94.8%)		79 (97.5%)	31 (88.6%)	
Does not know	13 (18.3%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Fatigue, N (%):			**<0.001**			0.461
No	25 (35.2%)	10 (8.62%)		6 (7.41%)	4 (11.4%)	
Yes	46 (64.8%)	85 (73.3%)		58 (71.6%)	27 (77.1%)	
Does not know	0 (0.00%)	21 (18.1%)		17 (21.0%)	4 (11.4%)	
Restorative sleep, N (%)	14 (19.7%)	29 (25.7%)	0.454	21 (25.9%)	8 (25.0%)	1.000
Chocking, N (%)	28 (40.0%)	50 (45.0%)	0.608	34 (42.5%)	16 (51.6%)	0.514
Nocturia, Median [Q1; Q3]	2.00 [1.00;3.00]	2.00 [1.00;3.00]	0.882	2.00 [0.00;3.00]	2.00 [1.00;3.00]	0.842
Epworth Sleepiness Scale at diagnosis, Mean (SD)	11.2 (5.45)	10.7 (5.26)	0.531	10.9 (5.27)	10.1 (5.28)	0.444
CPAP TREATMENT						
CPAP adaptation, N (%)	64 (90.1%)	111 (94.9%)	0.346	75 (92.6%)	36 (100%)	0.222
Nº CPAP titration required, N (%):			**<0.001**			1.000
1	56 (78.9%)	116 (99.1%)		80 (98.8%)	36 (100%)	
>1	15 (21.1%)	1 (0.85%)		1 (1.23%)	0 (0.00%)	
95th percentile pressure, cmH2O, Mean (SD)	11.0 (2.00)	10.1 (2.16)	**0.006**	9.93 (2.10)	10.5 (2.27)	0.222
Residual AHI, per h, Median [Q1; Q3]	1.60 [0.80;4.00]	4.00 [2.30;6.70]	**<0.001**	4.10 [2.20;7.55]	3.40 [2.58;4.62]	0.424
EARLY FOLLOW-UP (1 month)						
Follow-up visit attendance, N (%)	58 (90.6%)	111 (100%)	**0.004**	75 (100%)	36 (100%)	-
CPAP compliance (hours of daily use), Mean (SD)	4.79 (2.85)	4.33 (2.62)	0.292	4.21 (2.76)	4.58 (2.30)	0.470
CPAP compliance (>4h/night), N (%)	45 (70.3%)	70 (63.1%)	0.419	44 (58.7%)	26 (72.2%)	0.240
CPAP compliance (>5h/night), N (%)	40 (56.3%)	56 (47.9%)	0.329	37 (45.7%)	19 (52.8%)	0.611
Epworth change after CPAP treatment, Mean (SD)	7.12 (7.24)	5.29 (4.70)	0.104	5.00 (4.73)	5.90 (4.66)	0.380
Patient satisfaction (0- 10), Mean (SD)	7.69 (2.05)	9.02 (0.64)	**<0.001**	9.00 (0.64)	9.06 (0.64)	0.665

Table 3. Multivariate logistic models

A) RC - TC multivariate logistic model: CPAP adherence > 4 hours per night

	Univariate				Multivariate			
Predictors	*Odds Ratios*	*std. Error*	*CI*	*p*	*Odds Ratios*	*std. Error*	*CI*	*p*
(Intercept)	2.37	0.65	1.41 – 4.14	**0.002**	0.04	0.06	0.00 – 0.83	**0.042**
Telemedicine vs Retrospective	0.72	0.24	0.37 – 1.38	0.331	0.64	0.24	0.30 – 1.33	0.239
Age					1.05	0.02	1.02 – 1.09	**0.002**
Gender [Female]					1.21	0.47	0.58 – 2.62	0.614
BMI					1.02	0.02	0.97 – 1.07	0.517
Educational level [High School and Associated degree OR College and Graduate degree]					1.80	0.70	0.85 – 3.94	0.134
Apnea hipoapnea index (events per hour)					1.00	0.01	0.98 – 1.01	0.731
Epworth sleepiness scale at diagnosis					1.05	0.04	0.98 – 1.12	0.152
Observations	175				160			
R2 Tjur	0.005				0.088			
AIC	228.062				207.984			

B) TC_noAPP – TC_APP used multivariate logistic model: CPAP adherence > 4 hours per night

	Univariate				Multivariate			
Predictors	*Odds Ratios*	*std. Error*	*CI*	*p*	*Odds Ratios*	*std. Error*	*CI*	*p*
(Intercept)	1.42	0.33	0.90 – 2.27	0.135	0.00	0.00	0.00 – 0.01	**0.001**
APP used vs No-APP used	1.83	0.81	0.79 – 4.49	0.169	2.09	1.12	0.75 – 6.23	0.169
Age					1.10	0.03	1.05 – 1.16	**<0.001**
Gender [Female]					0.97	0.50	0.35 – 2.74	0.956
BMI					1.06	0.04	0.98 – 1.15	0.148
Educational level [High School and Associated degree OR College and Graduate degree]					3.94	2.28	1.33 – 13.04	**0.017**
Apnea hipoapnea index (events per hour)					1.02	0.01	1.00 – 1.04	0.132
Epworth sleepiness scale at diagnosis					1.05	0.05	0.96 – 1.15	0.289
Observations	111				100			
R2 Tjur	0.017				0.216			
AIC	148.248				125.753			

C) RC - TC multivariate linear model: Patient satisfaction

	Univariate				Multivariate 1				Multivariate 2			
Predictors	*Estimates*	*std. Error*	*CI*	*p*	*Estimates*	*std. Error*	*CI*	*p*	*Estimates*	*std. Error*	*CI*	*p*
				<0.00				**<0.00**				**<0.00**
(Intercept)	7.69	0.17	7.35 – 8.02	**1**	7.64	0.18	7.29 – 7.99	**1**	7.63	0.22	7.19 – 8.07	**1**
Telemedicine vs Retrospective				**<0.00**				**<0.00**				**<0.00**
	1.33	0.21	0.91 – 1.75	**1**	1.38	0.22	0.94 – 1.82	**1**	1.40	0.23	0.94 – 1.85	**1**
Age					0.04	0.11	-0.18 – 0.25	0.745	0.03	0.12	-0.20 – 0.26	0.794
BMI					0.10	0.11	-0.12 – 0.32	0.364	0.09	0.12	-0.15 – 0.32	0.463
Apnea hipoapnea index (events per hour)					-0.12	0.11	-0.33 – 0.09	0.242	-0.13	0.11	-0.34 – 0.09	0.248
Epworth sleepiness scale at diagnosis					0.24	0.11	0.02 – 0.45	**0.030**	0.24	0.11	0.02 – 0.45	**0.029**
Gender [Female]									0.01	0.23	-0.45 – 0.47	0.967
Educational level [High School and Associated degree OR College and Graduate degree]									0.02	0.24	-0.45 – 0.49	0.936
Observations	170				160				157			
R2 / R2 adjusted	0.190 / 0.185				0.227 / 0.202				0.232 / 0.196			
AIC	582.165				553.937				157			

Table 4 - Patients' survey on CPAP adaptation and follow-up

	Retrospective cohort (RC) vs Telemedicine cohort (TC)			Telemedicine cohort:TC-noAPP vs TC-APP		
	RC	**TC**	**p.value**	**TC_noAPP**	**TC_APP**	**p.value**
	N=61	*N=102*		N=69	N=33	
Satisfaction with the follow up, N (%):			**<0.001**			0.103
No	9 (14.8%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Partially	10 (16.4%)	2 (1.96%)		0 (0.00%)	2 (6.06%)	
Yes	42 (68.9%)	100 (98.0%)		69 (100%)	31 (93.9%)	
Easy access to healthcare professionals, N (%):			**<0.001**			**.**
No	12 (19.7%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Partially	13 (21.3%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Yes	36 (59.0%)	102 (100%)		69 (100%)	33 (100%)	
Confidence in the confidentiality of the data, N (%):			**0.018**			**.**
No	1 (1.64%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Partially	3 (4.92%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Yes	57 (93.4%)	102 (100%)		69 (100%)	33 (100%)	
Rather be followed telematically or in person (the opposite group), N (%):			**<0.001**			1.000
No	25 (41.0%)	96 (94.1%)		65 (94.2%)	31 (93.9%)	
Partially	14 (23.0%)	0 (0.00%)		0 (0.00%)	0 (0.00%)	
Yes	22 (36.1%)	6 (5.88%)		4 (5.80%)	2 (6.06%)	
Increase in number of hours of CPAP because of the follow up done, N (%):			0.063			0.**011**
No	19 (31.1%)	50 (49.0%)		38 (55.1%)	12 (36.4%)	
Partially	15 (24.6%)	15 (14.7%)		5 (7.25%)	10 (30.3%)	
Yes	27 (44.3%)	37 (36.3%)		26 (37.7%)	11 (33.3%)	
Use of the telemedicine and telemonitoring system again or recommendation of it to others, N (%):			.			0.390
No	0 (.%)	2 (1.96%)		1 (1.45%)	1 (3.03%)	
Partially	0 (.%)	2 (1.96%)		1 (1.45%)	1 (3.03%)	
Yes	0 (.%)	98 (96.1%)		67 (97.1%)	31 (93.9%)	

Table 5 - APP server data (TC-APP)

	N=36
Messages sent, N (%):	
No	14 (38.9%)
Yes	22 (61.1%)
Follow up questionnaires, N (%):	
No	11 (34.4%)
Yes	21 (65.6%)
Message initiation through the app, N (%):	
No messages	0 (0%)
Patient	16 (72.7%)
Sleep Unit Staff	6 (27.3%)
Number of medical messages, Median [25% ; 75%]	2.5 [1 ; 5.75]
Message subject, N (%):	
Greeting	1 (4.6%)
Adverse effect	15 (68.2%)
General question CPAP	2 (9.1%)
Question from the staff about an alert message	4 (18.2%)
Messages resulted in action to improve CPAP adaptation, N (%):	
No	12 (57.1%)
Yes	9 (42.9%)
Nasal congestion or obstruction when using CPAP, N (%):	
No	7 (63.6%)
Yes	3 (27.3%)
Does not know	1 (9.1%)
Air leaks with the use of CPAP, N (%):	
No	9 (81.8%)
Yes	2 (18.2%)
Does not know	0 (0%)
Skin marks or irritation with CPAP use, N (%):	
No	7 (63.6%)
Yes	4 (36.4%)
Does not know	0 (0%)
Dry mouth with CPAP use, N (%):	
No	6 (54.6%)
Yes	5 (45.5%)
Does not know	0 (0%)
Excessive air pressure with the use of CPAP, N (%):	
No	8 (80%)
Yes	2 (20%)
Does not know	0 (0%)
Chest or abdominal discomfort with CPAP use, N (%):	
No	7 (70%)
Yes	3 (30%)
Does not know	0 (0%)
Sleeping hours using CPAP, Mean (standard deviation)	6.36 (1.21)

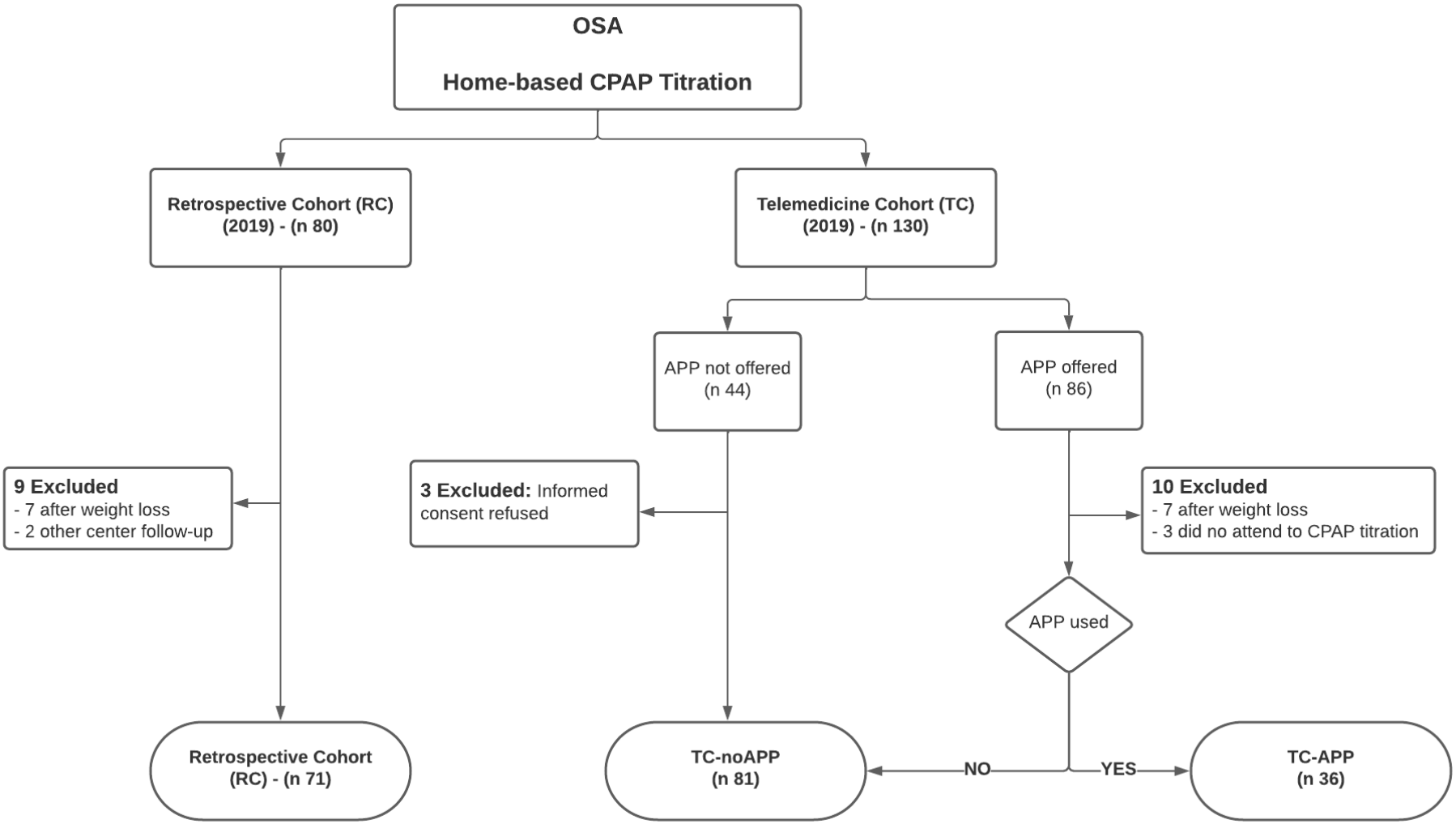

Figure 1. Flowchart