Improving PAP adherence

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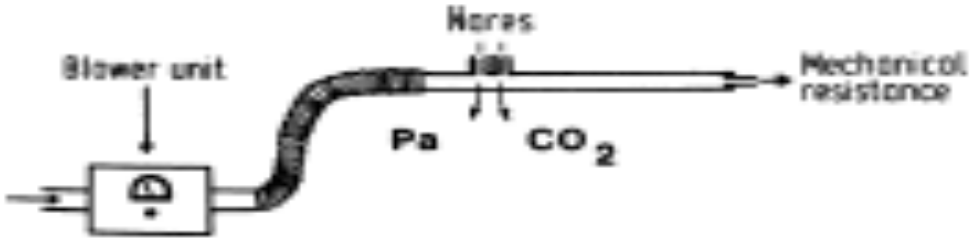
CPAP: an evolutionary treatment for OSA

The first CPAP machine was invented by Collin Sullivan in 1981 assembled from parts of vacuum cleaner

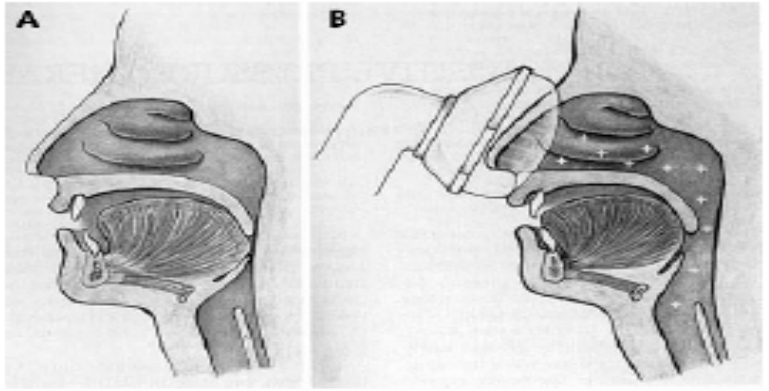
- The original CPAP device was described by Collin Sullivan in 1981, consisted of a vacuum blower motor with variable speed control. " HEAVY & LOUD"

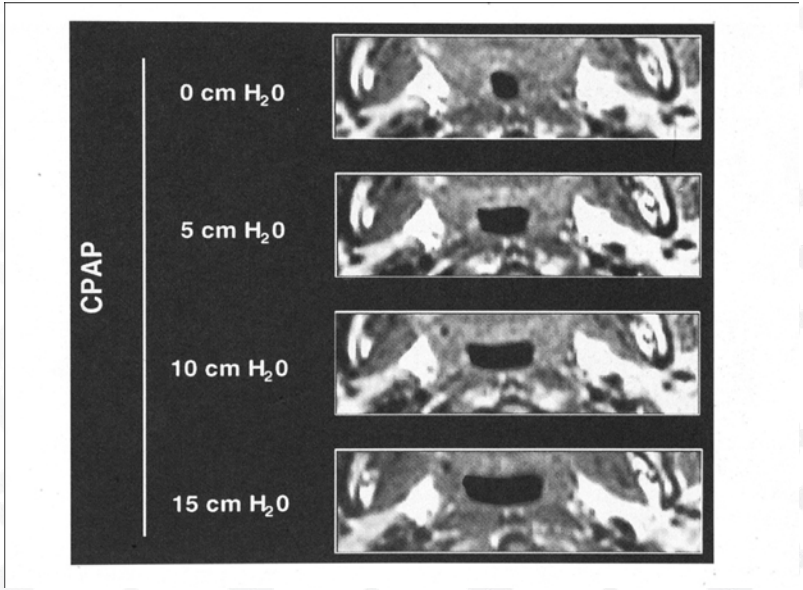


Sullivan CE, et al. Lancet 1981

Positive pressure and the upper airway

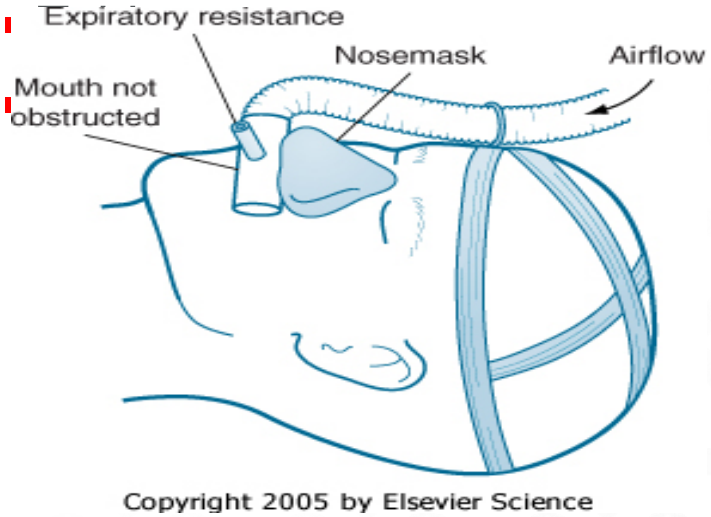
- ***Pneumatic splint*** Positive pressure provides a stent to offset the oropharyngeal collapse
- ***Increases in the functional residual*** capacity with increases in pharyngeal patency





Components of CPAP

- Machine



- Current status of CPAP use
- Determining the adherence: what is the adherence rate?
- Predictors of adherer vs non-adherer
- Interventions to improve PAP adherence
    - Equipment and technology
    - Behavioral and psychological aspects
    - Long-term follow ups

Current status of CPAP use

- Obstructive sleep apnea (OSA) is a common disease affecting 4-9% of the general population, leading to many fatal and non-fatal cardiovascular disease, accidents, and mortality.

- When used as prescribed, Continuous Positive Airway Pressure (CPAP) reduces daytime sleepiness, normalizes sleep architecture, and improve OSA-specific health outcomes.

- Although, CPAP is considered to be the standard first line treatment for OSA, the adherence rate is still low making treatment outcome suboptimal both in RCT and cohort.

Flattened Trends of CPAP use over the 2 decades

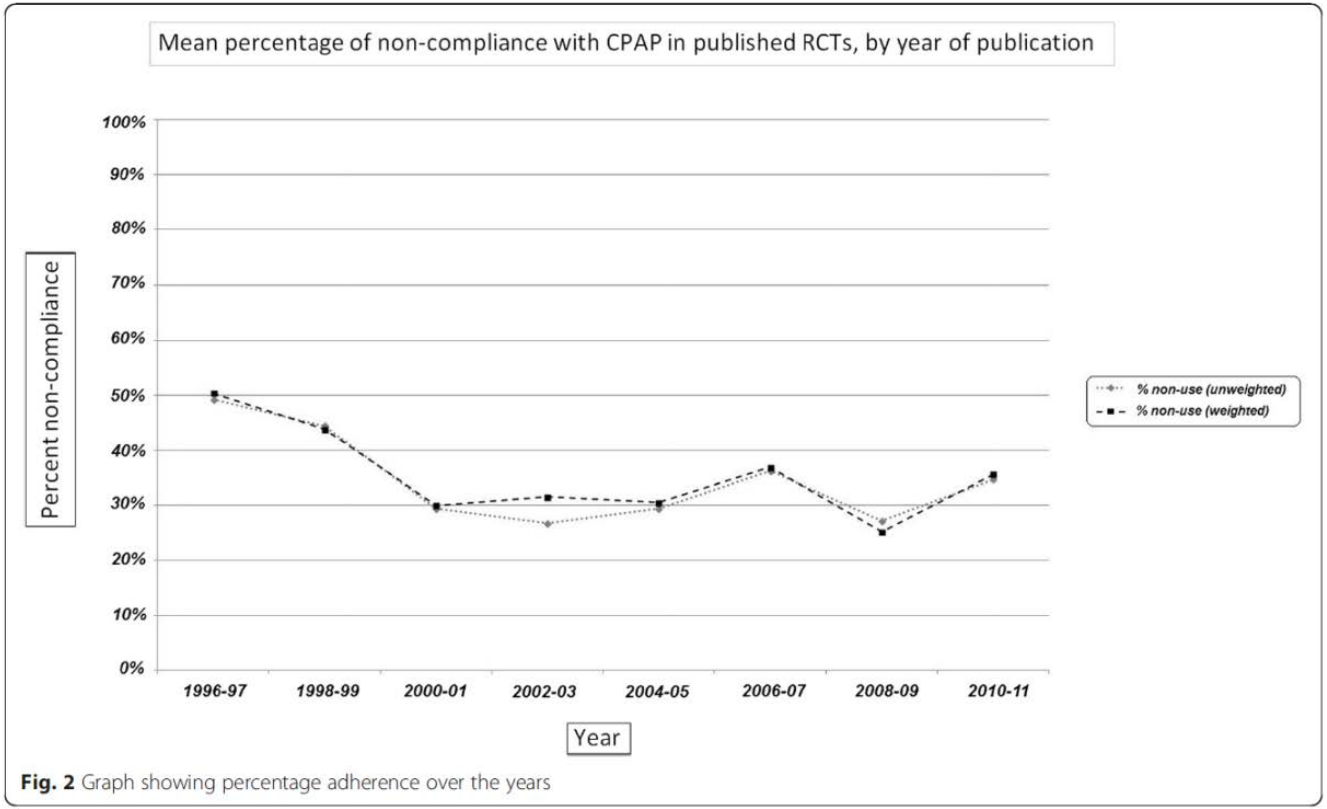


Fig. 2 Graph showing percentage adherence over the years

- 82 RCTs, Cohorts were included in the meta-analysis
- Weighted mean CPAP use was 4.46 and 36.3% non-adherence rate
- Behavioral intervention increases the mean use about 1 hour (4.7vs3.5 hours)
- Self reported adherence were overestimated by 32.7% compared to machine download data

Rosenberg, et al. Journal of Otolaryngology-Head and Neck Surgery; 2016:43

CPAP acceptance and adherence rates in Asia: Cohort data

Author/year	Country	Severity of OSA	Study period	Acceptance Rate (%)	Adherence Rate (%)
Lee, 2017	Singapore	Moderate-Severe	1 year	57.8	52.6
Wang Y, 2012	China	Severe	30 months	67	65
Hui DS, 2001	Hong Kong	Moderate, Severe	3 months	100	72
Tokunaga, 2013	Japan	Moderate, Severe	19 months	91	90
Tanahashi, 2012	Japan	Mild, moderate, severe	6 months	87	38
Hussain, 2014	Pakistan	Mild, moderate, severe	1 year	80	76
Yang MC, 2013	Taiwan	Mild, moderate, severe	9 months	40	64
Ramathibodi Sleep Center, 2018*	Thailand	Mild, moderate, severe	6 months	85	60

Lee, et al. Sleep Sci 2017;10:57-63
**Pengjam, et al. submitting for publication*

Defining the adherence definition

- Many studies referred to adherence as “using > 4 hours for more than 70% of the time”. However adherence should be defined based on evidence of improve in clinical outcome.

- Hours use to improve clinical outcome differ according to various outcomes
  - Daytime symptoms: sleepiness, functional outcomes
  - Cardiovascular outcomes:
  - Diabetic outcomes:

Controlling daytime symptoms

- **Hours of CPAP use require to control daytime symptoms**
  - 4 hours/night for self-reported sleepiness
  - 6 hours/night for objective sleepiness
  - 7.5 hours/night for functional status
  - 5.2 hours/night for memory impairment

Weaver, TE, et al. Sleep 2007;30:711-719
Antic NA, et al. Sleep 2011;34:111-119
Zimmerman ME, et al. Chest 2016;130:1772-1778

Optimal Adherence for controlling Cardiovascular Outcomes

- **Surrogate outcome**: **blood pressure**

  - lowering effect of CPAP from meta-analysis of RCTs showed reduction in SBP -3.2 mmHg , DBP-2.87 mmHg

  - Every 1 hour of CPAP use was associated with 1.4 mmHg reduction in mean BP

- **Sleepier patients may experience greater reduction from CPAP**

  - Each 5-point increase in baseline ESS was associated with a reduction in SBP 1.9 mmHg (*p=0.06*) and DBP of 1.4 mmHg (*p=0.04*)

Schein, et al. Journal of Hypertension, 2014

Haentjens P, et al. Arch Intern Med 2007;167::757-764

Montesi SB, et al. J Clin Sleep Med. 2012;8:587-596

Relationship Between Hours of CPAP Use and Achieving Normal Levels of Sleepiness and Daily Functioning.

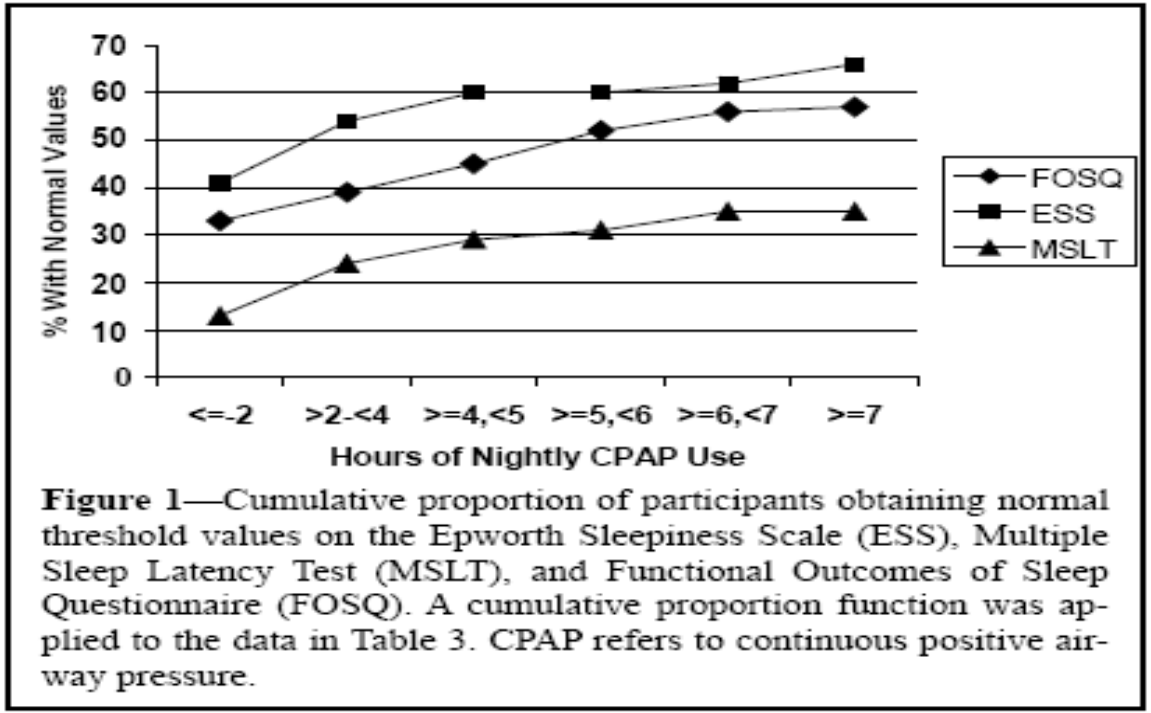


Figure 1—Cumulative proportion of participants obtaining normal threshold values on the Epworth Sleepiness Scale (ESS), Multiple Sleep Latency Test (MSLT), and Functional Outcomes of Sleep Questionnaire (FOSQ). A cumulative proportion function was applied to the data in Table 3. CPAP refers to continuous positive airway pressure.

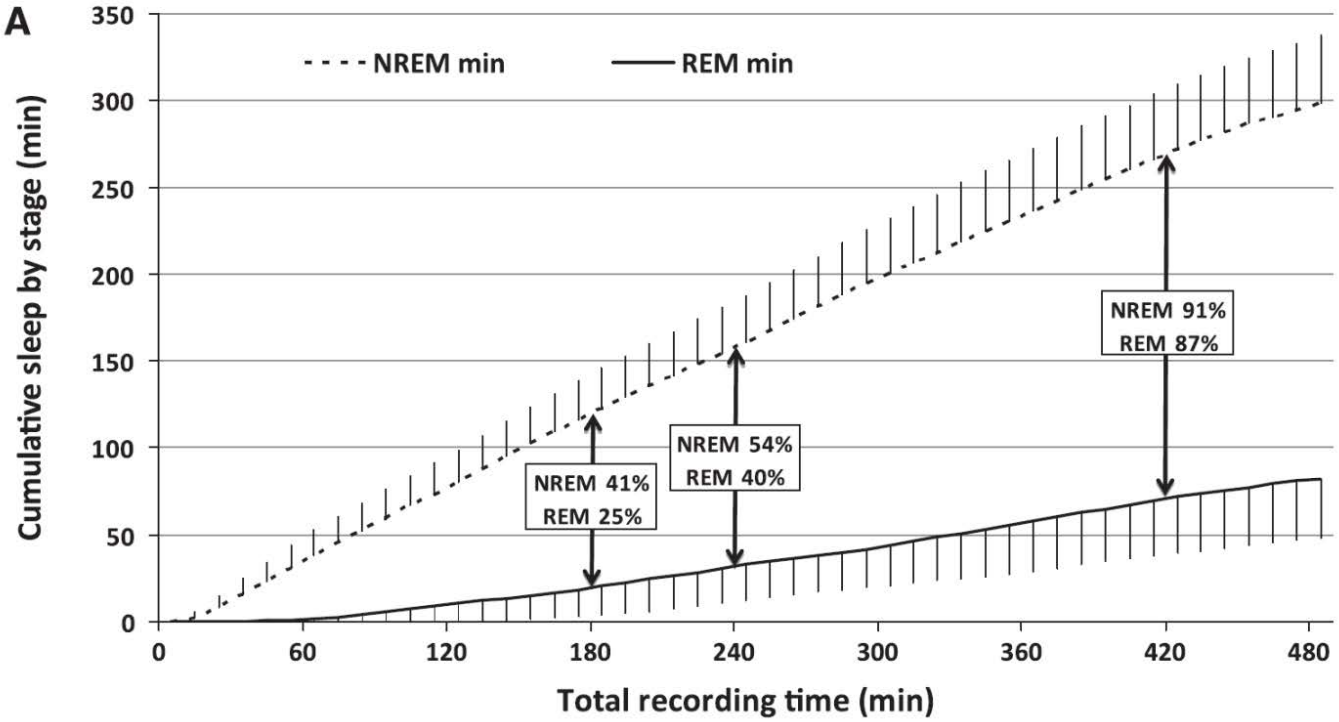
Weaver, TE, et al. Sleep 2007;30:711-719

CPAP use hour for controlling cardiovascular outcomes

- In a cohort studies, CPAP adherence had shown to reduce cardiovascular morbidities and mortalities compared to nonadherence in men, women, and elderly.
- Although, large scale RCTs reported negative results on cardiovascular morbidity and mortality based on intention-to-treat analysis, with average CPAP use 3.3 and 5 hours/night.
- It is too early to conclude that CVS risk is not attributable from OSA, but may be the level for beneficial CPAP use has not been reached.

Marin, JM, et al. Lancet 2005;365:1046-1053
Campos-Rodriguez, et al. Ann Intern Med.2012;156:115-122
Marinez-Garzia, MA, et al. Am J Respir Crit Care Med. 2012;146:909-916
Barbe F, et al. JAMA. 2012;307:2161-2168
McEvoy RD, et al. N Eng J Med. 2016;375:919-931
Peker Y, et al. Am J Respir Crit Care Med 2016;194:613-620.

Association of Obstructive sleep Apnea in Rapid Eye Movement Sleep with Reduced Glycemic control in Type 2 Diabetes: Therapeutic Implication



- REM AHI was associated with increasing level of HbA1C (p=0.008), but not NREM AHI (p=0.76)
- The model predicts

4 hour of CPAP use leave 60% of the REM sleep untreated with **0.25% reduction in HBA1c**

7 hour of CPAP use would cover **>85% of REM sleep** with decrease in **HBA1c by 1%**

- In Type2 DM, OSA during REM sleep may influence long-term glycemic control and metabolic effect of CPAP maynot be achieved with typical adherence of 4 hour/night

Grimaldi, D, et al. Diabetes Care. 2014;37:355-363

Impact of OSA during REM sleep on hypertension and cardiovascular disease

- Data from Wisconsin Sleep Cohort showed that **OSA isolated to REM sleep** *(REM AHI>15 with NREM AHI<5)* was **independently associated with prevalent and incident hypertension and non-dipping of nocturnal BP.**
- Those with prevalent CVS disease at baseline, having **REM OSA had hazard ratio of 2.56(95% CI 1.46-4.47 for composite CVS disease.**
- Another study also showed that **severe OSA isolated to REM sleep doubles the risk for recurrent CVS risks**
- **Adherence rate among REM-OSA** (23.3%;3.8 ±1.8 hrs) maybe **lower** compared to non-stage specific OSA (33.3%;5.1 ±2.1 hrs) in a 1 year cohort study.

Mokhlesi B, et al.2015 Thorax;70:1062-1069
Aurora RE, et al. Am J Respir Cirt Care Med 2018;197:653-660
Almeneessier A, et al. J Thorac Dis 2017;9:3755-3765

Other considerations

- Adherence is often considered as hours used per night, not as proportion of total sleep time. 4-hour use = insufficient to cover the whole night and especially during REM sleep

- Even in the absence of CVS effects, CPAP treatment in OSA has impact on sleepiness, mood, and functional status, it is important to focus on **increasing CPAP adherence as a key focus.**

Becker, JP, et al. Chest 2019

Predictors of adherence/nonadherence

- In a retrospective cohort of 695 patients with newly diagnosed OSA prescribed for CPAP with median follow up of 3 years. Data showed adherence rate of **89% for severe OSA, 71% for moderate OSA, and 55% for mild OSA.**

- Predictors for **CPAP nonadherence** were **AHI (HR 0.963, *p*<0.001), ESS (HR 0.963, *p*=0.001),** and **smoking (HR 1.576, p=0.022)** after adjusting for age, gender, and comorbidity

Jacobson AR, et al. PLOS ONE. 2017:12

Types of adherent and nonadherent CPAP users

Adherent CPAP user

- Define risks associated with OSA
- Identify outcome expectation from outset
- Have fewer barriers than facilitators
- Facilitators less important later with treatment use
- Develop goals and reasons for CPAP use
- Describe positive belief in ability to use CPAP even with potential or experienced difficulties
- Proximate social influences prominent in decisions to pursue diagnosis and treatment

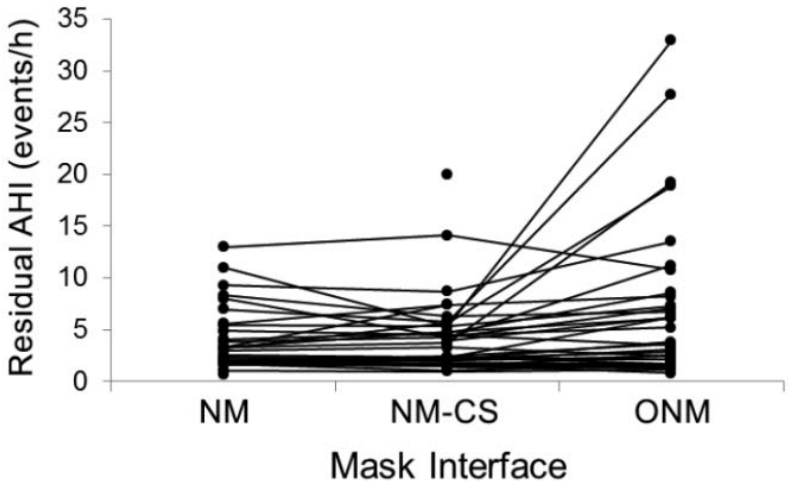
Sawyer, et al. Qual Health Res.2010;20:873-92

Nonadherent CPAP use

- Unable to define risks associated with OSA
- Describe few outcomes expectations
- Do not recognize own symptoms
- Describe barriers as more influential on CPAP use than facilitators
- Facilitator of treatment absent or unrecognized
- Describe low belief in ability to use CPAP
- Describe early negative experiences with CPAP, reinforcing low belief in ability to use CPAP
- Unable to identify positive responses to CPAP during early treatment

Comparing efficacy, mask leak, patient adherence and patient preference of 3 different CPAP interfaces to treat moderate to severe OSA

Figure 2—Residual AHI with each mask interface type.

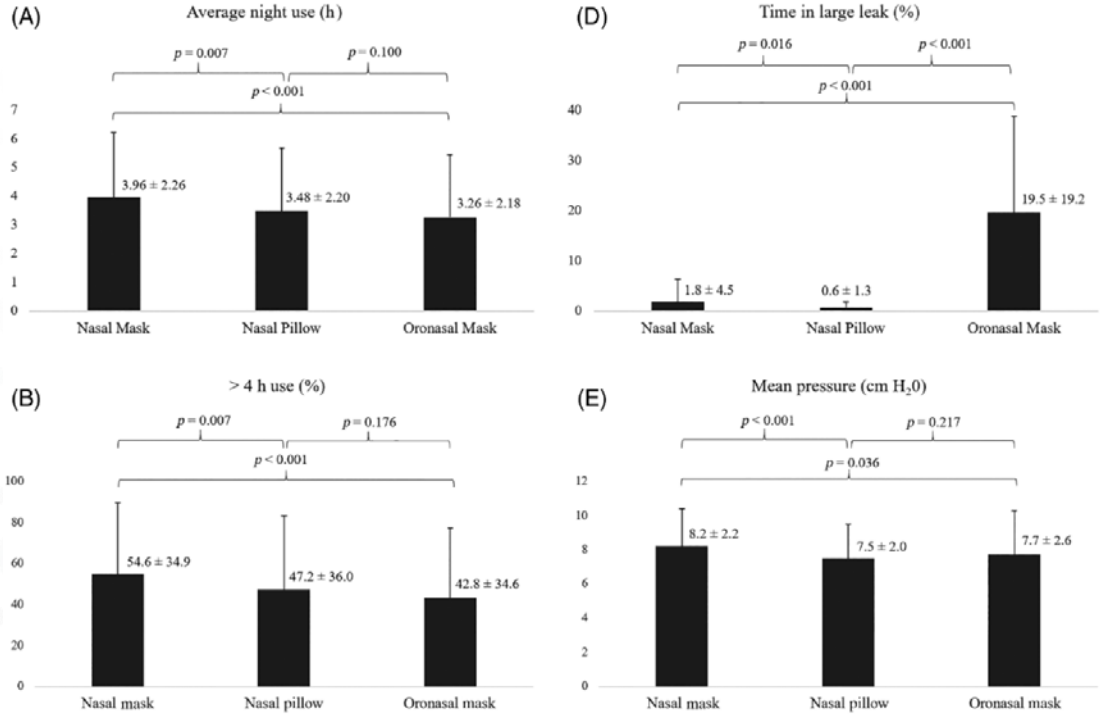


Rowland, et al. J Clin Sleep Med.2018;14:101-6

- A Cross-over RCT for 4 weeks randomly assign to nasal mask (NM), nasal mask-chinstrap (NM-CS), and oronasal mask (ONM)
- CPAP adherence was not different, but residual AHI was higher in ONM than NM and NM-chinstrap.
- Patient satisfaction/preference, and quality of sleep were better for NM with fewer leaks and mask fit problem
- Nasal mask (+/- chinstrap) should be first choice for OSA patients with CPAP

Choosing the right mask for your Asian patients with sleep apnoea: A randomized crossover trial of CPAP interfaces

- **A randomized crossover trial of mask interfaces in CPAP therapy in moderate to severe OSA** with **nasal mask, pillow mask, and oronasal mask** (n=85)
- Patients had **better adherence with nasal mask compared to oronasal mask and pillow**
- **Residual AHI was higher in oronasal masks** compared to **pillow and nasal masks**
- **Nasal mask are the preferred interface during CPAP initiation**. However, in subgroup of patients with lower NOSE score showed best adherence with oronasal mask



Goh KJ , et al. Respirology 2019; 24: 278-285

Factors	
Disease and patients characteristics	-Disease severity - Sleepiness (higher CPAP use) - Insomnia-phenotype (lower CPAP use) - Upper airway/nasal patency - REM OSA vs non-stage specific OSA
	Ethnics (white versus minority)
	Socio-economic status, education level Reimbursement vs out-of-pocket
Device related	Heated humdification Auto-CPAP, Flexible pressure
Side effect	Early troubleshooting Airleak, mask discomfort, intolerance, nasal congestion/dryness, skin redness/ulceration, gastric distention, eye discomfort, irritation, noisy machine
Psychological factors	Claustrophobia, personality type, social support

NEW RESEARCH

JCSM
Journal of Clinical Sleep Medicine
http://dx.doi.org/10.5664/jcsm.2476

A Brief Survey of Patients' First Impression after CPAP Titration Predicts Future CPAP Adherence: A Pilot Study

Jay S. Balachandran, M.D.[1]; Xiaohong Yu, M.D.[2]; Kristen Wroblewski, M.S.[3]; Babak Mokhlesi, M.D., M.Sc., F.A.A.S.M.[1]

[1]Sleep Disorders Center, Section of Pulmonary and Critical Care, Department of Medicine, [2]Department of Psychiatry, [3]Department of Health Studies, Biostatistics Laboratory, University of Chicago, Chicago, IL

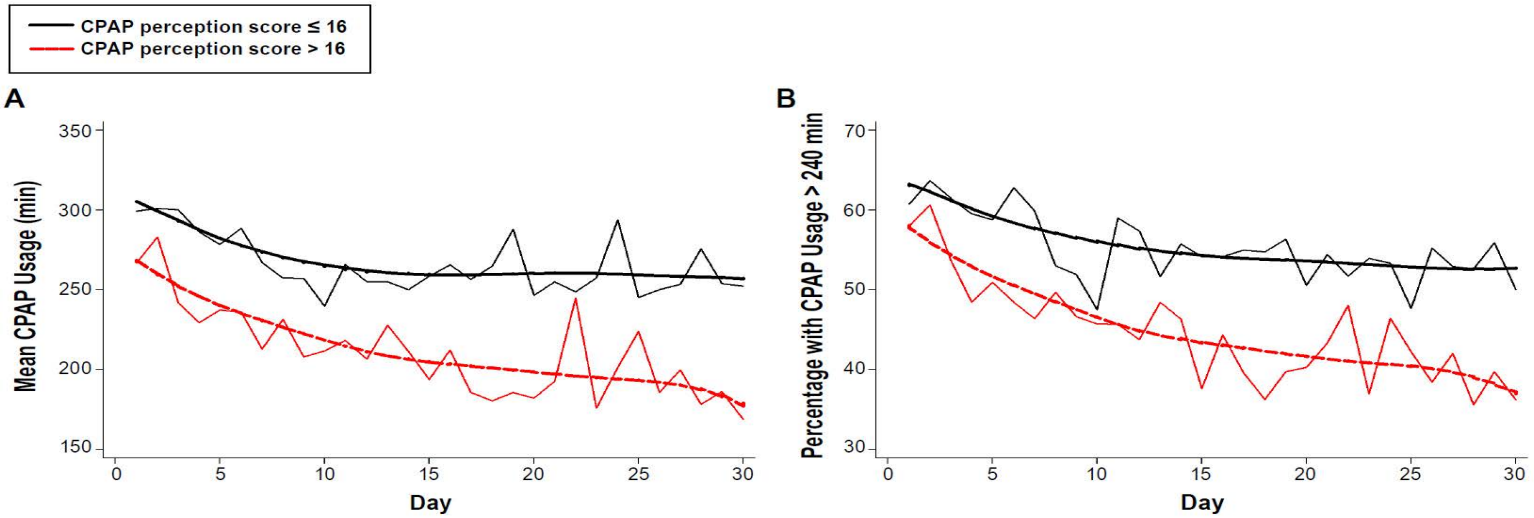
1. How much difficulty did you have tolerating CPAP?
2. How uncomfortable was the mask?
3. How uncomfortable was the CPAP pressure?
4. What is the likelihood of you wearing the equipment at night almost every night?
5. How beneficial do you think CPAP is going to be for your health and sleep>
6. What is your attitude towards CPAP therapy?

Table 3—Stepwise linear regression model of mean CPAP adherence over the first 30 days of therapy

	Beta coefficient (minutes)	95% CI	p value
CPAP perception score (per each point in a scale of 4 to 40)	-3.3	-5.5, -1.0	0.005
African American race	-46	-80, -12	0.007
Non-sleep specialist ordering PSG	-69	-108, -31	< 0.001

Balachandran, et al. J of Clin Sleep Med 2013

Figure 2—CPAP perception score predicts nightly CPAP use and percentage of patients with ≥ 4 hours nightly CPAP use



The mean CPAP perception score was used to create two categories of patients: poor CPAP perception (scores > 16) and good CPAP perception (scores ≤ 16). Higher scores on the CPAP perception score were associated with decreased nightly CPAP usage **(A)** $p = 0.001$. Similarly, higher scores on the CPAP perception score were associated with a decreased percentage of patients using CPAP ≥ 4 hours each night **(B)** $p < 0.001$. Lowess smooth curves were added to summary plots to aid in assessment of trends.

Balachandran, et al. J of Clin Sleep Med 2013

Factors that determine CPAP adherence

- **Pretreatment:**
  - Referral source: patients, bedpartner, physician
  - Knowledge of OSA, and perception of CPAP treatment
  - Involvement of bedpartner in education and treatment initiation
  - patient' s tendency of problem solving
  - assessment of claustrophobic tendencies
  - Evaluation of nasal resistance
  - Exposure to CPAP before initiation of therapy

Weaver T. Proc am thorac soc 2008

With treatment initiation

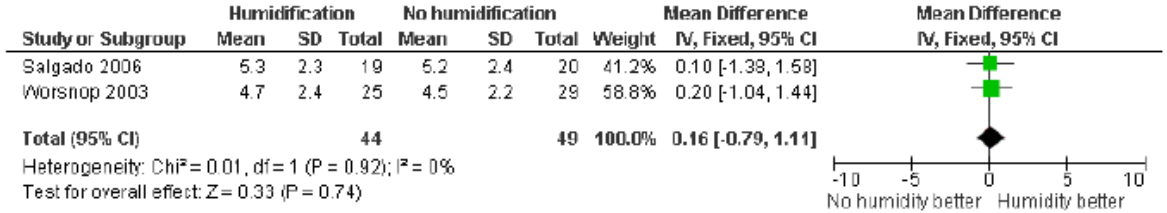
- Heated humidification
- Early follow-up
- Assessment of CPAP use and associated outcomes
- Assessment of patient perception of treatment and symptom-related treatment response
- Troubleshooting problems immediately- especially the first week of treatment
- Evaluation for residual sleepiness
- Retitrate if residual events suspected

Weaver T. Proc am thorac soc 2008

Humidification

There were conflicting findings between studies. Two parallel group found no significant difference in machine usage, whereas a cross-over study found a significant difference

Figure 10. Forest plot of comparison: 4 Heated humidification + fixed pressure CPAP versus fixed pressure CPAP alone, outcome: 4.1 Machine usage (hours/night) - 1st arm parallel studies.



Pressure modification for improving usage of CPAP machine in adults with obstructive sleep apnoea. Cochrane Review 2009

Intervention to improve CPAP adherence:

A structured, multidisciplinary, cost-effective model for long term CPAP

- Technological components
- Educational and behavioural components
- Telemedicine

Humidifiers

- RCT, Cross-over study of 38 OSA pts. With 3 interventions of heated humidity, cold passover humidity, and washout period. (3 wk treatment, 2 wk wash-out)
- **CPAP use with heated humidifier was greater than CPAP use with cold passover humidity and CPAP alone (5.52 ±2.1vs4.93 ± 2.2, p=0.008).**
- No difference found for **compliance between CPAP alone and CPAP cold passover**.
- **Patients reported were more satisfaction with heated humidity, awaking feeling more refreshed, less dryness of throat (p≤0.05)without difference in side effect, ESS**.

Massie., et al Chest 1998.

Humidification

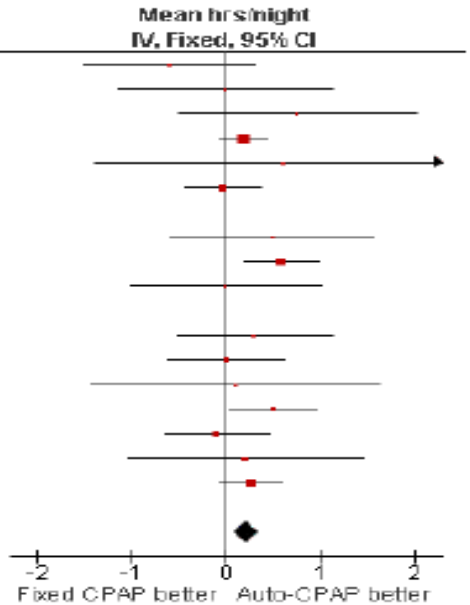
- Prospective Randomized cross over study done in Thailand
- 20 moderate to severe OSA subjects with nasopharyngeal symptoms
- Even in a tropical climate area, CPAP adherence and quality of life appeared to improve when heated
- humidification was employed in subjects with moderate to severe OSA with nasopharyngeal symptoms post-split-night polysomnography. The improvement may be related to a reduction in the dry throat/sore throat symptom.

Soudorn C, Muntham D, Reutrakul S, Chirakalwasan N. Respir Care. 2016 May 24.

Figure 3. Forest plot of comparison: 1 Auto-CPAP versus fixed CPAP, outcome: 1.2 Machine usage - cross-over studies.

Study or Subgroup	Mean hrs/night	SE	Auto-CPAP Total	Fixed CPAP Total	Weight	Mean hrs/night IV, Fixed, 95% CI
d'Ortho 2000	-0.6	0.4617	25	25	2.2%	-0.60 [-1.50, 0.30]
Galetke 2008	-0.01	0.587	20	20	1.4%	-0.01 [-1.16, 1.14]
Hudgel 2000	0.76	0.647	29	29	1.1%	0.76 [-0.51, 2.03]
Hukins 2004	0.19	0.13	46	46	27.6%	0.19 [-0.06, 0.44]
Hussain 2004	0.6	1.02	10	10	0.4%	0.60 [-1.40, 2.60]
Jarvis 2006	-0.035	0.2015	20	20	11.5%	-0.04 [-0.43, 0.36]
Kendrick 2002	0	0	0	0		Not estimable
Marrone 2004	0.5	0.55	22	22	1.5%	0.50 [-0.58, 1.58]
Massie 2003	0.58	0.2	44	44	11.6%	0.58 [0.19, 0.97]
Nolan 2007	0	0.525	29	29	1.7%	0.00 [-1.03, 1.03]
Noseda 2004	0	0	0	0		Not estimable
Nussbaumer 2006	0.3	0.4234	30	30	2.6%	0.30 [-0.53, 1.13]
Randerath 2001	0	0.31	52	52	4.8%	0.00 [-0.61, 0.61]
Rochford 2006	0.1	0.7857	13	13	0.8%	0.10 [-1.44, 1.64]
Roslig 2003	0.5	0.2379	30	30	8.2%	0.50 [0.03, 0.97]
Senn 2003	-0.1	0.28	29	29	5.9%	-0.10 [-0.65, 0.45]
Teschler 2000	0.2	0.6377	10	10	1.1%	0.20 [-1.05, 1.45]
To 2008	0.26	0.16326	41	41	17.5%	0.26 [-0.06, 0.58]
Total (95% CI)			**450**	**450**	**100.0%**	**0.21 [0.08, 0.35]**

Heterogeneity: Chi² = 12.78, df = 16 (P = 0.62); I² = 0%
Test for overall effect: Z = 3.12 (P = 0.002)



Pressure modification for improving usage of CPAP machine in adults with obstructive sleep apnoea. Cochrane Review 2009

Analysis 01.07. Comparison 01 Auto-CPAP versus fixed CPAP, Outcome 07 Patient preference (auto CPAP/not auto CPAP)

Review: Interventions to improve compliance with continuous positive airway pressure for obstructive sleep apnoea

Comparison: 01 Auto-CPAP versus fixed CPAP

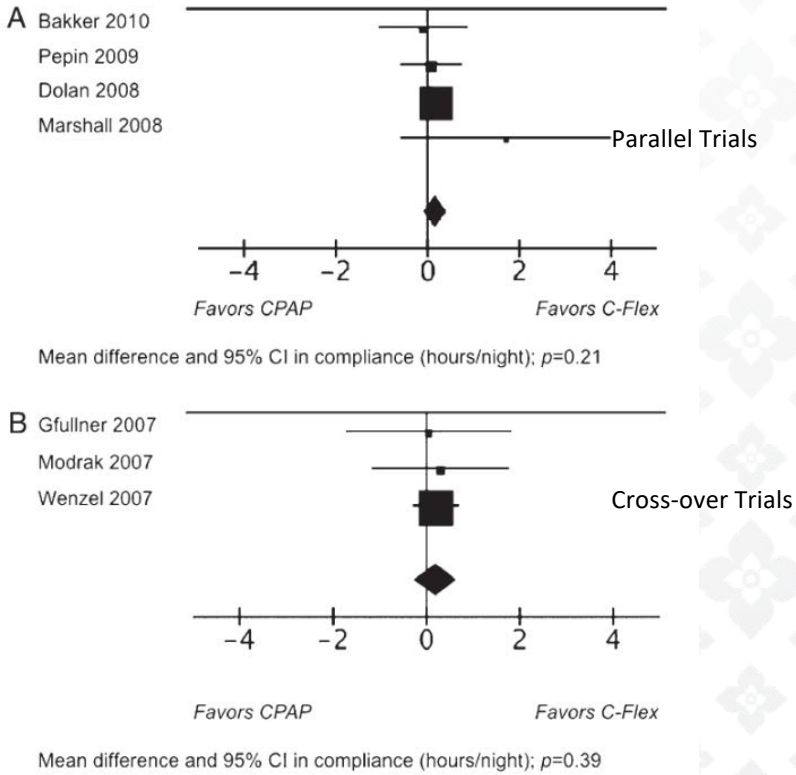
Outcome: 07 Patient preference (auto CPAP/not auto CPAP)

Study	Auto-CPAP n/N	Not auto-CPAP n/N	Relative Risk (Random) 95% CI	Relative Risk (Random) 95% CI
Randerath 2001	35/47	12/47		2.92 [1.74, 4.89]
Rostig 2003	18/30	12/30		1.50 [0.89, 2.54]
Senn 2003	4/29	25/29		0.16 [0.06, 0.40]
Torvaldsson 2003	10/11	1/11		10.00 [1.53, 65.41]
d'Ortho 2000	15/25	10/25		1.50 [0.84, 2.67]

Flexible Pressure Delivery Modification of Continuous Positive Airway Pressure for Obstructive Sleep Apnea Does not improve compliance with therapy: Systematic Review and Meta-Analysis

- 10 Studies (n=599) were included, data was extracted from **7 studies (n=514) using flexible pressure for OSA for meta-analysis**

- **Flexible pressure did not improve compliance** compared with CPAP in either **parallel** (0.16h; 95%CI -0.90-0.41; *p=0.21*)or **cross-over trials** (0.20h; 95%CI -0.26-0.66; *p=0.21)*



Bakker JP, et al. Chest 2011;139:1322-1330

BiPAP vs Fixed CPAP

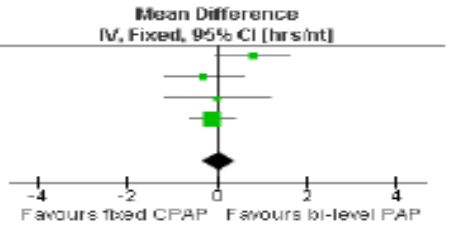
3 studies: No significant difference in compliance.

No difference in preference in 1 study.

Figure 7. Forest plot of comparison: 2 Bi-level PAP versus fixed CPAP, outcome: 2.1 Machine usage (hours/night) - 1st arm/parallel studies [hrs/nt].

Study or Subgroup	Bi-level PAP Mean [hrs/nt]	Bi-level PAP SD [hrs/nt]	Bi-level PAP Total	Fixed CPAP Mean [hrs/nt]	Fixed CPAP SD [hrs/nt]	Fixed CPAP Total	Weight	Mean Difference IV, Fixed, 95% CI [hrs/nt]
Ballard 2007	3.7	2	51	2.9	2.3	53	20.0%	0.80 [-0.03, 1.63]
Blau 2007	5.3	1.5	15	5.6	1	17	17.1%	-0.30 [-1.20, 0.60]
Gay 2003	5.6	1.7	12	5.6	1.4	15	9.6%	0.00 [-1.19, 1.19]
Reeves-Hoché 1995	4.9	1.17	26	5	0.72	36	53.3%	-0.10 [-0.61, 0.41]
Total (95% CI)			104			121	100.0%	0.06 [-0.31, 0.43]

Heterogeneity: Chi² = 4.08, df = 3 (P = 0.25); I² = 27%
Test for overall effect: Z = 0.29 (P = 0.77)



Interventions to improve compliance with CPAP for OSA. Haniffa.Cochrane Review 2008

The Efficacy of a Brief Motivational Enhancement Education Program on CPAP Adherence in OSA

A Randomized Controlled Trial

Agnes Y. K. Lai, DN; Daniel Y. T. Fong, PhD; Jamie C. M. Lam, MD, FCCP; Terri E. Weaver, PhD; and Mary S. M. Ip, MD, FCCP

- **A RCT of 100 newly diagnosed OSA patients** random into either **brief motivational enhancement education program** or **usual care (control)**
- Program focus on enhance **subject's knowledge, motivation, and self-efficacy** by means of 25-min video, 20-min patient center interview, and 10-min telephone follow-up.
- Outcomes were **self-reported sleepiness, adherence, and quality of life at 1 and 3 months**
- Intervention group had **better CPAP use by 2 hour/d** (Cohen d=1.33, p<0.001), **4-fold increase in adherence rate, p<0.001,** and greater improvement in ESS compared to control group

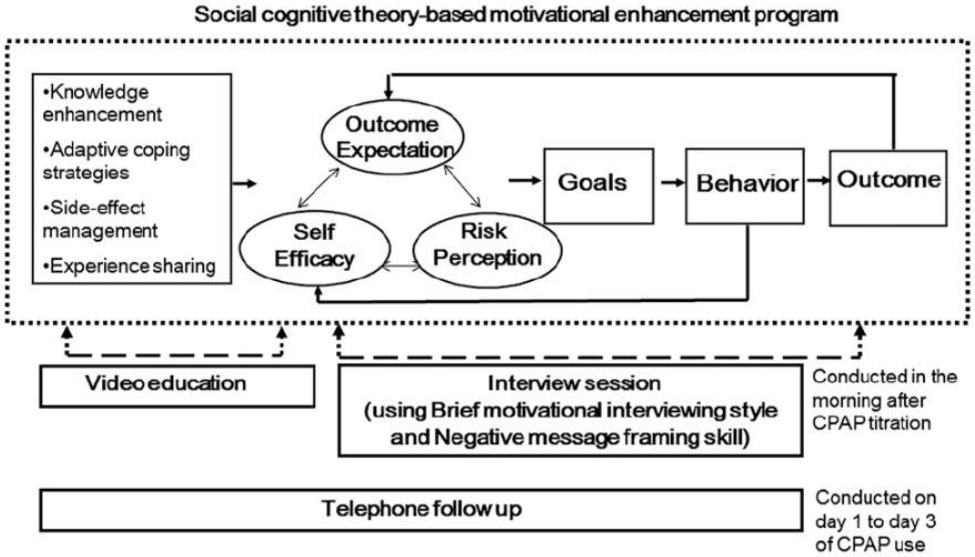
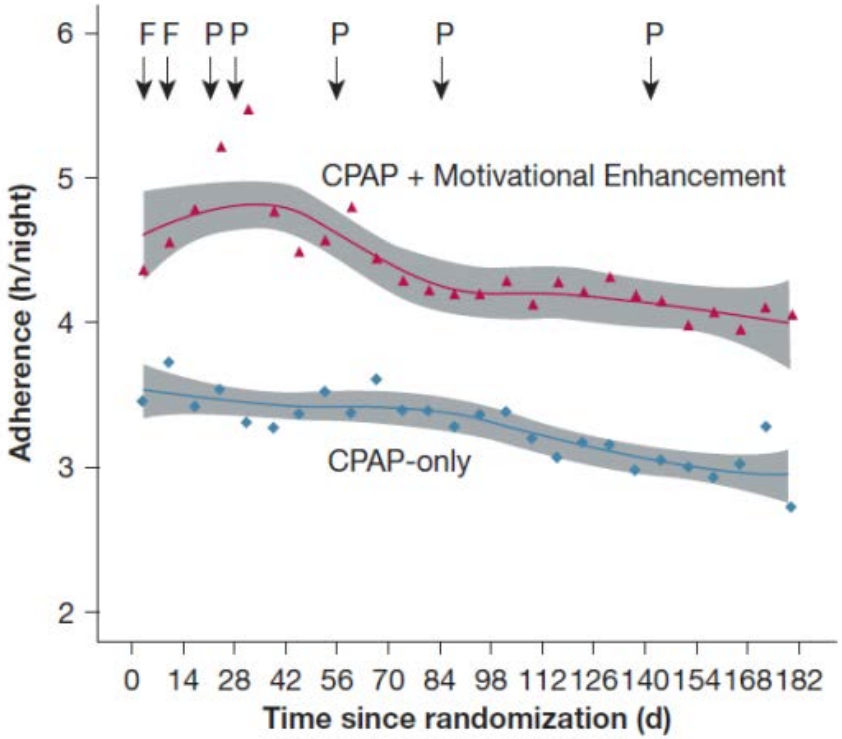


Figure 1 – *The conceptual framework and time of conduction of the motivational enhancement education program.*

Lai, et al. Chest 2014; 146:600-610

Motivational enhancement for increasing adherence to CPAP: A randomized controlled trial

- **A open-label RCT of CPAP +ME (n=41**) compared to **CPAP alone (standardized CPAP support)(n=42)**
- In **moderate to severe OSA patients** (age 45-75 years) **without marked sleepiness and with either CVD or at risk**
- **ME was delivered by psychologist**
- (2 appointments and 6 phone calls over 32 weeks)
- **Intention-to-treat analysis** was applied to compare objective CPAP adherence
- In fully adjusted model, **CPAP+ME showed higher average nightly adherence at 6 months (+99.0 min higher, p=0.003)** and **97 min higher at 12 months** in subset of patients (n=52)



Bakker, et al. Chest 2016;150:337-345

Comparison 1. Increased practical support and encouragement during follow-up + CPAP versus usual care + CPAP

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Machine usage (hours/night)	13	803	Mean Difference (IV, Random, 95% CI)	0.82 [0.36, 1.27]
2 Machine usage, sensitivity analysis: excluding participants aware of machine usage monitoring	6	378	Mean Difference (IV, Fixed, 95% CI)	1.07 [0.61, 1.52]
3 Machine usage, sensitivity analysis: adherence in control group < four hours/night	8	471	Mean Difference (IV, Fixed, 95% CI)	1.36 [0.96, 1.76]
4 N deemed adherent (≥ four hours/night)	4	268	Odds Ratio (M-H, Fixed, 95% CI)	2.06 [1.22, 3.47]
5 Epworth Sleepiness Scale scores	8	501	Mean Difference (IV, Random, 95% CI)	-0.60 [-1.81, 0.62]
6 Quality of life: Functional Outcomes of Sleep Questionnaire	2	70	Mean Difference (IV, Fixed, 95% CI)	0.98 [-0.84, 2.79]
7 Quality of life: Sleep Apnoea Quality of Life Index (SAQLI)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8 Mood	3	312	Mean Difference (IV, Fixed, 95% CI)	-0.94 [-1.55, -0.33]
8.1 HAD Scale for Anxiety	1	80	Mean Difference (IV, Fixed, 95% CI)	-1.10 [-2.95, 0.75]
8.2 HAD Scale for Depression	3	232	Mean Difference (IV, Fixed, 95% CI)	-0.93 [-1.57, -0.28]
9 Withdrawals	12	903	Odds Ratio (M-H, Fixed, 95% CI)	0.65 [0.44, 0.97]
10 AHI on treatment	2	115	Mean Difference (IV, Fixed, 95% CI)	-0.07 [-1.62, 1.48]
11 Maintenance of Wakefulness Test (MWT)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Wozniak DR, et al. Cochrane Database of Systematic Reviews 2014;1

Educational, supportive and behavioural interventions to improve usage of continuous positive airway pressure machines in adults with obstructive sleep apnoea (Review)

Comparison 2. Educational interventions + CPAP versus usual care + CPAP

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Machine usage (hours/night)	7	508	Mean Difference (IV, Fixed, 95% CI)	0.60 [0.27, 0.93]
2 N deemed adherent (≥ four hours/night)	3	285	Odds Ratio (M-H, Fixed, 95% CI)	1.80 [1.09, 2.95]
3 Epworth Sleepiness Scale scores	5	336	Mean Difference (IV, Fixed, 95% CI)	-1.17 [-2.07, -0.26]
4 Quality of life: Sleep Apnoea Quality of Life Index (SAQLI)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 HAD Scale for Depression	2	152	Mean Difference (IV, Fixed, 95% CI)	-0.52 [-1.25, 0.22]
6 Withdrawal	8	683	Odds Ratio (M-H, Fixed, 95% CI)	0.67 [0.45, 0.98]

Wozniak DR, et al. Cochrane Database of Systematic Reviews 2014;1

Educational, supportive and behavioural interventions to improve usage of continuous positive airway pressure machines in adults with obstructive sleep apnoea (Review)

Comparison 3. Behavioural therapy + CPAP versus control + CPAP

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Machine usage (hours/night)	6	584	Mean Difference (Random, 95% CI)	1.44 [0.43, 2.45]
2 Sensitivity analysis: excluding participants aware of machine usage monitoring	5		Mean Difference (Fixed, 95% CI)	1.54 [0.99, 2.09]
3 N deemed adherent (≥ four hours/night)	3	358	Odds Ratio (M-H, Fixed, 95% CI)	2.23 [1.45, 3.45]
4 Epworth Sleepiness Scale score	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Quality of life: Functional Outcomes of Sleep Questionnaire	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6 Withdrawal	5	609	Odds Ratio (M-H, Fixed, 95% CI)	0.85 [0.57, 1.25]

Wozniak DR, et al. Cochrane Database of Systematic Reviews 2014;1

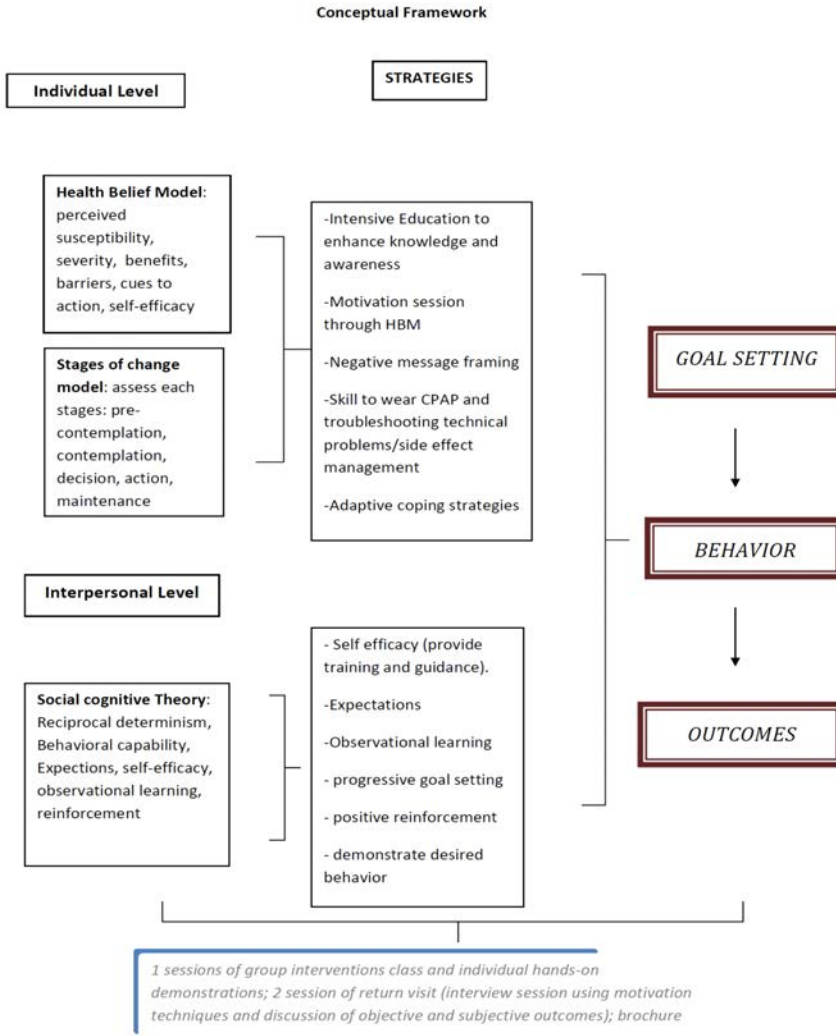
Conceptual Framework for CPAP-motivation education class based on the Health belief Model

- **Translation into the real-world routine**

CPAP clinic





Predictors of initial acceptance of continuous positive airway pressure (CPAP) in obstructive sleep apnea patients after intensive educational-behavioral program.

Janejira Pengjam [1], Visasiri Tantrakul [1,2], Worakot Suwansathit [1]
Ramathibodi Hospital Sleep Disorder Center Mahidol University, Bangkok, Thailand [1]
Division of Pulmonary and Critical Care, Medicine Department, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand [2]

Mean(SD)	Total N=247	CPAP acceptance N=210	CPAP denial N=37	*p*-value
Age, years (Mean, SD)	55.36±13.0	55.85±12.7	52.6±14.4	.160
Gender, Male (n, %)	155(62%)	136(64.8%)	19(51.4%)	.120
BMI, kg/m2 (Mean, SD)	28.8±5.9	29.0±5.9	28.2±5.8	.466
ESS (Mean, SD)	11.1±5.1	10.6±4.8	11.2±5.1	.540
AHI, events/hr. (median, IQR)	41.5(46.4)	43.1(46.5)	25.5(42.1)	.01
Minimum Spo2 (Mean, SD)	79.6±10.9	78.6±11.1	84.8±8.5	<0.001
Severity (n, %)				.009
- Mild	30(12.1%)	21(70.0%)	9(30.0%)	
- Moderate	60(24.3)	48(80.0%)	12(20.0%)	
- Severe	157(63.6%)	141(89.9%)	16(10.2%)	
Coverage (n, %)				<0.001
- Government reimbursement	147(59.5%)	132(89.9%)	15(10.2%)	
- Self-affordable	69(27.9%)	63(91.3%)	6(8.7%)	
- No reimbursement	31(12.6%)	15(48.1%)	16(51.6%)	
No of trials (n, %)				<0.001
- No trial	3(1.2%)			
- 1 trial	102(41.3%)	79(77.5%)	23(22.5%)	
- 2 trials	75(30.0%)	67(89.3%)	8(10.7%)	
- 3 trials	67(27.1%)	64(95.5%)	3(4.5%)	

Predictors of initial acceptance of continuous positive airway pressure (CPAP) in obstructive sleep apnea patients after intensive educational-behavioral program.

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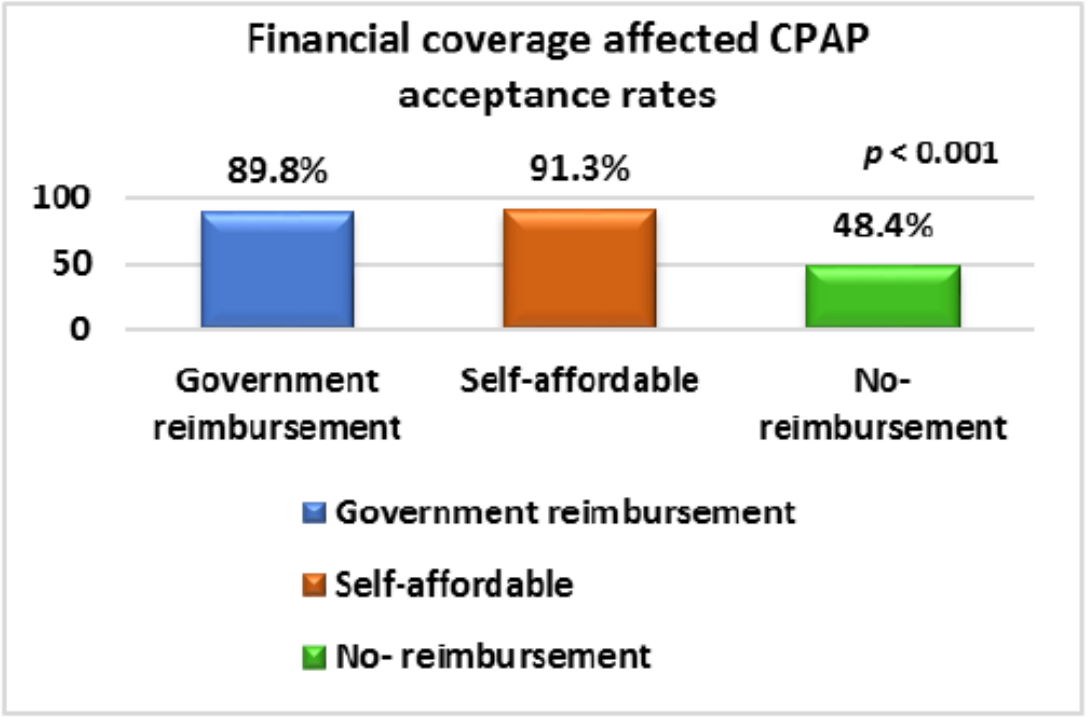
Table 3 Multivariate analyses for predictors for CPAP acceptance

Predictors for CPAP acceptance	Odd ratio	95% CI	*p*-value
OSA severity			
- ***AHI<15 events/hour***			
- ***AHI≥15 events/hour***	4.1	1.20 – 13.88	0.024
Financial coverage			
- ***No reimbursement***			
- ***Self-affordable***	12.1	3.37 – 43.31	<0.001
- ***Government reimbursement***	8.1	2.91 – 22.36	<0.001
Numbers of trials			
- ***1 trial***			
- ***2 trials***	2.8	1.05 – 7.53	0.04
- ***3 trials***	8.6	2.09 – 35.35	0.003

Conclusions: Intensive educational-behavioral program resulted in high initial acceptance rate of CPAP in OSA patients. Multiple trials of CPAP should be offered as more success occurred with increasing numbers of trials. Predictors of CPAP acceptance were severe OSA and no financial shortage. Only half of patients without government reimbursement accepted CPAP, despite medical indications. Alternative OSA treatment should be available for CPAP-denial patients.

Presented at the World Sleep Meeting 2015, and submitting for publication

Table 2 Financial coverage and CPAP acceptance rate.



Submitting for publication

Telemedicine

- **In a multicenter-RCTs of 139 subjects with cost-effective analysis,** telemedicine for CPAP monitoring of OSA patients compared to hospital based care **resulted in comparable compliance rate at 6 months,** but **more cost-saving on transport and less lost productivity**.

- **A RCT for telehealth program for CPAP adherence reduces labor and yield similar adherence and efficacy** compared to standard of care (**adherence rate 83% vs 73% and CPAP use 5.1 ±1.9 vs 4.7 ± 2.1 hours) at 30 days.**
- =Digital patient engagement tool to enhance CPAP adherence

Isetta V, et al. Thorax 2015;70:1054-1061
Munafo D, et al. Sleep Breath 2016;20:777-785

Short-term CPAP adherence in obstructive sleep apnea: a big data analysis using real world data

- **De-identified data form large cloud database of PAP user during 2014-2017** in the US were analyzed
- Device usage information were **transmitted remotely by Air10 platform** devices in encrypted form
- **Patients engagement tool**, My Air were also available on 2014, and iOS app on 2016

Table 1
Adherence data from the first 90 days of therapy.

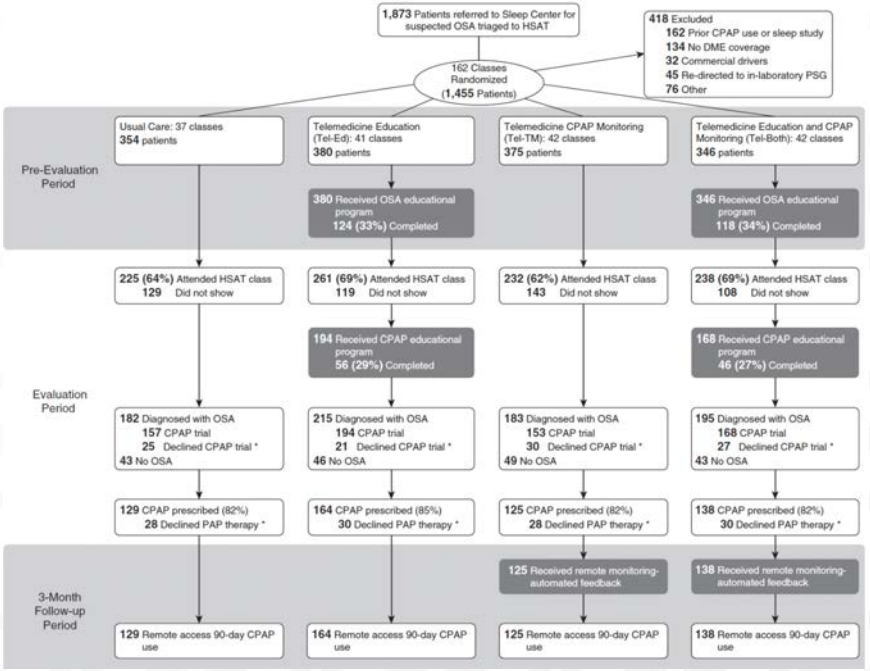
Adherence measures	Values (n = 2,621,182) Median (IQR)[a]
CMS compliance in first 90 days, n (%)	1,955,961 (74.6)
Time to achieve CMS compliance, days	23.00 (21.00, 27.00)
Device usage, h/session	6.18 (4.79, 7.35)
Daily usage (all days), h/night	5.54 (3.42, 7.04)
Proportion of days with non-zero usage, %	93.3 (72.2, 98.9)
Proportion of days compliant (usage ≥ 4 h/night), %	80.0 (46.7, 95.6)

CMS, Center for Medicare and Medicaid Services; IQR, interquartile range; SD, standard deviation. CMS Compliance definition: ≥4 hours' PAP use on 70% of nights in a consecutive 30-day period in the first 90 days of therapy.

Cistulli PA, et al. Sleep Medicine 2019, in press

Effect of Telemedicine Education and Telemonitoring on Continuous Positive Airway Pressure Adherence

- **A four-arm, randomized, factorial design clinical trial** of 556 OSA patients
- 2 telemedicine intervention were implemented **(web-based OSA education;Tel-Ed)** and **CPAP telemonitoring with automated patient feedback (Tel-TM)**
- Randomization include
  - Usual care
  - Tel-Ed added
  - Tel-TM added
  - Tel-Ed and Tel-TM (Tel-both)



Hwang D, et al. Am J Respir Crit Care 2019

Table 3. CPAP Use and Subjective Outcomes 90 Days after CPAP Dispensation

	Usual Care	Tel-Ed	Tel-TM	Tel-Both	Tel-Ed Effect (95% CI), *P* Value	Tel-TM Effect (95% CI), *P* Value	Tel-Both Effect (95% CI), *P* Value
	n = 129	*n* = 163	*n* = 125	*n* = 138			
Days used, %	64.8 ± 34.2	68.6 ± 31.3	76.6 ± 28.3	78.3 ± 28.3	2.8 (−2.3 to 7.9), 0.28	10.6 (5.5 to 15.7), <0.0001	13.4 (6.1 to 20.8), 0.0004
Average usage on all days, h	3.8 ± 2.5	4.0 ± 2.4	4.4 ± 2.2	4.8 ± 2.3	0.3 (−0.1 to 0.7), 0.10	0.8 (0.4 to 1.15), 0.0002	1.1 (0.5 to 1.7), 0.0002
Average usage on days used, h	5.2 ± 1.8	5.2 ± 1.8	5.3 ± 1.7	5.8 ± 1.6	0.2 (−0.1 to 0.5), 0.13	0.4 (0.1 to 0.7), 0.006	0.6 (0.2 to 1.0), 0.003
Medicare adherence, *n* (%)	69 (53.5)	100 (61.0)	82 (65.6)	101 (73.2)	1.4* (1.0 to 2.0), 0.07	1.7* (1.2 to 2.4), 0.003	2.4* (1.4 to 3.9), 0.001
	n = 83	*n* = 113	*n* = 90	*n* = 93			
Change in ESS score†	−3.7 ± 4.7	−2.8 ± 6.4	−3.7 ± 5.2	−3.0 ± 3.7	0.8 (−0.2 to 1.9), 0.13	−0.14 (−1.2 to 0.9), 0.80	0.7 (−0.9 to 2.3), 0.38
Change in FOSQ-10 score†	−14.2 ± 10.3	−9.9 ± 12.9	−10.9 ± 11.2	−11.3 ± 12.8	1.9 (−0.8 to 4.5), 0.16	0.6 (−2.0 to 3.3), 0.64	2.5 (−1.3 to 6.4), 0.20

Definition of abbreviations: CI = confidence interval; CPAP = continuous positive airway pressure; ESS = Epworth Sleepiness Scale; FOSQ = Functional Outcomes of Sleep Questionnaire; Tel-both = telemedicine-based education and telemonitoring; Tel-Ed = telemedicine-based education; Tel-TM = telemedicine-based telemonitoring.
Values represent means ± SD or number of patients (%).
*Reported effect is an odds ratio.
†Although CPAP usage data were available for all patients, ESS and FOSQ-10 were available only for those who kept their 3-month follow-up appointment.

Hwang D, et al. Am J Respir Crit Care 2019

Summary

- **Current status of CPAP use**: remained low and problematic, despite CPAP being the gold standard for OSA
- **Determining the adherence definition:** there is no clear-cut evidence for the threshold for CPAP use required to improve clinical outcomes. “The longer, the better”
- **Predictors of adherer vs non-adherer** depends on patients and disease characteristics, device-related issue, side effects, and psychological issue
- **Interventions to improve PAP adherence**
  - Equipment and technology
  - Behavioral and psychological aspects
  - Adherence maybe improved with current telemedicine practice