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**Title:** Adherence to Continuous Positive Airway Pressure Therapy in Obstructive Sleep Apnoea Sufferers: A Theoretical Approach to Treatment Adherence and Intervention

**Author names and affiliations:**

***Ms Sara Olsen<sup>1</sup>***

Email: [uqsolse2@uq.edu.au](mailto:uqsolse2@uq.edu.au)

***Dr Simon Smith<sup>2</sup>***

Email: [Simon.Smith@qut.edu.au](mailto:Simon.Smith@qut.edu.au)

***Professor Tian Oei<sup>1</sup>***

Email: [Oei@psy.uq.edu.au](mailto:Oei@psy.uq.edu.au)

1. School of Psychology, The University of Queensland, St Lucia, QLD, Australia
2. Centre for Accident Research and road Safety (CARRS-Q), Queensland University of Technology, Carseldine, QLD, Australia

**Corresponding author:** Sara Olsen

School of Psychology

University of Queensland

St Lucia, 4072

Queensland, Australia 406

Phone: 61 (07) 33457326

Fax: 61 (07) 33654466

E-mail address: [uqsolse2@uq.edu.au](mailto:uqsolse2@uq.edu.au)

*Abstract*

Obstructive Sleep Apnoea (OSA) is a common sleep disorder associated with significant health, quality of life and psychosocial problems. The aims of this review are to investigate the contribution of psychological constructs and theory to the assessment and treatment of OSA. Adherence to CPAP treatment remains a primary concern for improving treatment outcomes for OSA. Modifiable, psychological constructs of self-efficacy, coping, social support, treatment satisfaction and self-reported daytime sleepiness improve the prediction of CPAP adherence. These predictors are particularly robust in the context of a theoretical model. Social Cognition Theory (SCT) and Health Belief Model (HBM) are emerging as promising psychological models for understanding patient acceptance and adherence to CPAP treatment. An overview of psychologically informed interventions for CPAP use is presented. Education based interventions have promise, but the strongest and robust findings are emerging from theory-driven interventions. Specifically, Cognitive Behaviourally informed interventions and Motivational Interventions demonstrate consistent and large effect sizes in improving CPAP adherence rates.

THE PSYCHOLOGY OF OBSTRUCTIVE SLEEP APNOEA:  
A THEORETICAL APPROACH TO TREATMENT ADHERENCE AND  
INTERVENTION

Obstructive Sleep Apnoea (OSA) is a common sleep disorder characterised by collapse of the upper airway during sleep. Continuous Positive Airway Pressure Therapy (CPAP) is the most effective treatment for this disorder, but is consistently associated with suboptimal adherence rates. Unitary, modifiable psychological predictors of adherence have only recently been investigated from a theoretical perspective. Investigation of the theorised inter-relationships between these predictors, accounting for moderating and mediating relationships between them, has been lacking. This has resulted in much inconsistency in the literature.

Previous research investigating modifiable psychological constructs of CPAP adherence will be critically reviewed. The primary goal of this review is to present a new, integrated, theoretically sound psychological model of CPAP adherence that predicts patient *acceptance* and *adherence* to treatment. It will be argued that this model will provide a basis for the development of psychological interventions designed to improve overall CPAP adherence rates and treatment outcomes.

*Clinical Presentation and Health Consequences of Obstructive Sleep Apnoea*

Obstructive Sleep Apnoea (OSA) is associated with obstructions of the upper airway during sleep, which are caused by collapse of the dilator muscles and soft tissues of the pharyngeal wall. OSA may be diagnosed based on the presence of 5 or more of these respiratory events (Apnoea-Hypopnoea Index > 5) with concurrent evidence of OSA symptoms (daytime sleepiness, snoring and choking arousals from sleep). Alternatively, OSA is also diagnosed when patients display an AHI of greater than 15 events per hour

with no subjective report of these additional symptoms (Chesson et al., 1997; ICSD-2, 2005; Malhotra & White, 2002).

The two main clinical features of OSA are the respiratory disturbances, and the arousals from sleep needed to reinstate breathing. These two features lead to the two main clinical consequences of the disorder, hypoxia of the brain and the heart, and sleep fragmentation. Daytime sleepiness and hypoxia of the brain are associated with cognitive deficits, such as impaired working memory and attention (Aloia, Ilniczky, Di Dio, Perlis, Greenblatt, & Giles, 2003; Gale & Hopkins, 2004). Hypoxia of the heart increases the risk of heart problems including hypertension (Coughlin, Mawdsley, Mugarza, Wilding & Calverley, 2007; ICSD-2, 2005; Jordan et al., 2005; Malhotra & White, 2002). Patients with OSA are also at higher risk for Type II diabetes and stroke (Malhotra & White, 2002). Daytime sleepiness effects the patients' and their partner's quality of life (Parish & Lyng, 2003) and there is a high rate of comorbid anxiety and depression in this sample (ICSD-2, 2005; Kingshott, Vennelle, Hoy, Engleman, Deary & Douglas, 2000; Parish & Lyng, 2003; Patel, White, Malhotra, Stanchina, & Ayas, 2003; Veale, Poussin, Benes, Pepin, & Levy, 2002). The effects of sleepiness and impaired concentration is most obvious in the car accident risk odds-ratio of 7.3 over five years compared to individuals of similar demographic status without OSA (Young, Peppard, & Gottlieb, 2002).

#### *Prevalence of OSA*

The prevalence of OSA varies according to the defined criteria (ICSD-2, 2005). When the criteria for diagnosis requires an  $AHI > 5$  and self-reported daytime sleepiness, snoring and/or choking arousals, the estimated American prevalence of OSA is 4% for men and 2% for women. Up to 24% of men and 9% of women in the population have an  $AHI > 5$  without any associated symptoms of sleepiness, snoring or choking arousals (American Academy of Sleep Medicine, 1999; ICSD-2, 2005; Malhotra & White, 2002; Young et al.,

2002). Sleep apnoea is consistently more prevalent in males, with a male to female ratio of up to 8:1 (Perlis & Lichstein, 2003).

### *Treatment of OSA*

The current “Gold Standard” treatment for OSA is CPAP therapy. Pressurised air is administered through a nasal (nCPAP) or full face mask. This pressurised air functions as a pneumatic splint for the upper airway, preventing it from collapse. The pressure is titrated to a level that reduces the individual patient’s AHI to less than 5 events per hour (Malhotra, Ayas, & Epstein, 2000; Stepnowsky & Moore, 2003).

CPAP use reduces the risk of several adverse outcomes of OSA. There is a general reduction in the number of physician claims and in the length of hospital stays for patients on CPAP (Malhotra et al., 2000). CPAP users are also at reduced risk for motor vehicle accidents compared to non-CPAP users (Engleman, Asgari-Jirhandeh, McLeod, Ramsay, Deary, & Douglas, 1996; Young et al., 2002). Recent evidence suggests that CPAP may also be effective in reducing negative psychosocial and improving mental health outcomes of these patients (Fidan, Ünlü, Sezer, Geçici, & Kara, 2007). The reduced daytime sleepiness noted during CPAP treatment is also associated with improvements in general quality of life for both the patient (Weaver, Maislin, Dinges, Bloxham, George, Greenberg, et al., 2007) and their partner (Kiely & McNicholas, 1997; Kingshott et al., 2000; McMahan, Foresman, & Chisholm, 2003). Despite the numerous positive outcomes experienced by patients who use CPAP, the effectiveness of this treatment is limited by suboptimal adherence rates.

### *Adherence to CPAP*

CPAP treatment of OSA can be awkward, and requires considerable alteration to a patient’s lifestyle (Malhotra et al., 2000). It has been estimated that 15 - 30% of patients do not accept CPAP treatment from the outset, that is, before or during their titration study

(Collard, Pieters, Aubert, Delguste, & Rodenstein, 1997; Fletcher & Lockett, 1991). This early pattern of CPAP use is critical for determining continued patterns of use (Weaver, Grunstein, 2008). Of those who do initially accept the treatment and take it home, 25 - 50% of patients fail to adhere optimally to the treatment (Zozula & Rosen, 2001). In the long term, up to 25% of patients stop using the treatment by the third year (Engleman & Wild, 2003).

Studies addressing adherence to CPAP up to five years follow-up, indicate that patients still using CPAP in the long term can be expected to use their CPAP machine, on average, between 4 and 5 hours per night at the prescribed pressure (Aloia, Arnedt, Stepnowsky, Hecht, & Borrelli, 2005; Bennet, Langford, Stradling, & Davies, 1998; Engleman et al., 1996; Engleman & Wild, 2003; Kingshott et al., 2000; Krieger, 1992; Lewis Seale, Bartle, Watkins, Watkins, & Ebden, 2004; Pieters, Collard, Aubert, Dury, Delguste, & Rodenstein, 1996; Reeves-Hoche, Meck, & Zwillich, 1994; Sage, Southcott, & Brown, 2001). A meter reading on CPAP machines provides an accurate measure of the number of hours that patients are using CPAP at pressure per night. Use of more than 4 hours per night has been quantified in the literature as “good” adherence (Collard et al., 1997; Haniffa, Lasserson, & Smith, 2004; Kingshott et al., 2000). However, this represents use of CPAP as prescribed for up to only half of the night. No dose-response definition for optimal CPAP use currently exists. However, recent research suggests that a linear dose-response curve is appropriate, whereby greater use during sleep is associated with greater improvement in daily functioning and reduced daytime sleepiness (Weaver et al., 2007). Without dosing guidelines, clinician goals for patient adherence tend to be for the patient to use the device as much as possible whilst sleeping.

### *Patient-reported reasons for not using CPAP*

The reasons reported by patients for not using CPAP are usually associated with the side effects of the treatment. The most common side effects, reported in 15 to 45% of patients, are skin irritation, nose stuffiness and air leaks around the mask (Zozula & Rosen, 2001). Less common, but equally significant reported problems, are claustrophobic reactions to the mask, problems with spontaneous intimacy with the bed partner, and the noise of the machine (Engleman et al., 1996; Hui et al., 2001; Zozula & Rosen, 2001). Specific modifications to the CPAP device and interface (such as humidifiers, pads on the bridge of the nose to reduce irritation and reduced noise from the machine) have lessened or removed many but not all of these side effects. However, there has not been a corresponding increase in adherence rates proportional to the amount of reduction in side effects experienced with these newer machines (Haniffa et al., 2004; Malhotra et al., 2000; Patel et al., 2003; Perlis & Lichstein, 2003; Stepnowsky, Marler, & Ancoli-Isreal, 2002). This suggests that the problem of CPAP adherence is not fully explained by mechanical issues with the CPAP device.

Investigation of psychological and motivational factors in CPAP adherence has led to a shift in the focus of patient treatment. Targeting patient attitudes towards the treatment, and improving these, has become a viable research avenue (Brostrom, Stromberg, Martensson, Ulander, Harder, & Svanborg, 2007; Weaver & Grunstein, 2008). The following sections of this review will outline physiological and demographic predictors of CPAP adherence. Following this, recent research evidence investigating psychological modifiable predictors of CPAP adherence will be evaluated with the aim of identifying modifiable constructs that can be incorporated in the context of an inclusive theoretical model predictive of patient *acceptance* and *adherence* to treatment.



*Physiological and Demographic Predictors of Adherence*

Many empirical studies have investigated general predictors of CPAP adherence. CPAP use may be associated with demographic factors such as male gender (Lewis et al., 2004; McArdle et al., 1999; Popescu, Latham, Allgar, & Elliot, 2001; Zozula & Rosen, 2001) lower age (McArdle et al., 1999; Zozula & Rosen, 2001) and the absence of a comorbid pulmonary disease (Lewis et al., 2004; McArdle et al., 1999). There is large variability in the literature regarding the predictive power of physiological indices of OSA severity.

Greater adherence to CPAP appears to be associated with objective and subjective improvements in disease variables of sleep quality and daytime sleepiness (Collard et al., 1997; Drake et al., 2003; Meurice et al., 1994; Popescu et al., 2001). Some studies have noted correlations (typically between  $r = .2$  and  $r = .4$ ) between the AHI and adherence (Drake et al., 2003; Edinger, Carwile, Miller, Hope, & Mayti, 1994; Engleman & Wild, 2003; Hui et al., 2001; Krieger, 1992; Lewis et al., 2004; McArdle et al., 1999; Meurice et al., 1994; Popescu et al., 2001; Zozula & Rosen, 2001). Adherence is less consistently associated with lower prescribed CPAP pressure (CPAP pressure <12cm) (Engleman & Wild, 2003; Zozula & Rosen, 2001), higher BMI (BMI>30) (Edinger et al., 1994; McArdle et al., 1999; Popescu et al., 2001; Zozula & Rosen, 2001) and higher level of education (Hui et al., 2001; Kribbs et al., 1993).

While demographic and physiological factors assist in the prediction of CPAP adherence, linear combinations of these physiological and demographic predictors rarely explain more than 10-15% of the variance in CPAP adherence (Engleman & Wild, 2003). Moreover, poor adherence rates are not specific to OSA or to CPAP. Studies of adherence to prescribed treatments for asthma (Bosley, Fosbury, & Cochrane, 1995), narcolepsy (Rogers, Aldrich, Berrios, & Rosenberg, 1997) and diabetes (Balkrishnan et al., 2003) have

shown that even with non-invasive pill or inhaler treatments with minor side effects, 40 - 50% of patients do not take the medication as prescribed (Clark & Becker, 1998; DiMatteo, Giordani, Lepper, & Croghan, 2002). Therefore, although treatment adherence is a significant problem for OSA patients, it is not a problem unique to this syndrome.

#### *Motivational/Psychological factors in adherence to treatment*

In a variety of chronic disorders requiring consistent adherence to a treatment regime (for example: diabetes, asthma and heart disease), social, emotional, personality and cognitive factors have been found to enhance the prediction of adherence (Connor & Norman, 1996; Kavanagh, Gooley, & Wilson, 1993). Inclusion of psychological variables to physiological variables in predicting CPAP adherence has been found to substantially improve prediction (Edinger et al., 1994; Olsen, Smith, Oei & Douglas, in press; Stepnowsky, Bardwell, Moore, Ancoli-Isreal, & Dimsdale, 2002; Stepnowsky, Marler et al., 2002). Given these findings, there has been a call for the identification of psychological predictors of CPAP adherence that are amenable to intervention (Aloia, Arnedt, Riggs, Hecht, & Borrelli, 2004; Aloia et al., 2005; Drake et al., 2003; Engleman & Wild, 2003; Perlis & Lichstein, 2003).

#### *Psychological Predictors of Adherence*

Physiological indices of the severity of sleep disordered breathing (for example, AHI) are not reliably correlated with patients' reported subjective symptom severity and quality of life (Chervin & Aldrich, 1999; ICSD-2, 2005; Zezirian, Harrison, Ancoli-Isreal, Redline, Ensrud, et al., 2007). This indicates that a patients' subjective *perception* of the problem may not necessarily reflect the objective severity of the illness. Thus, objective severity may not reflect their *need* for treatment. The impact of these beliefs and motivations on CPAP use has only recently gained recognition within the OSA literature.

Table 1 reports studies assessing the impact of psychological factors on CPAP adherence returned from Psyc-Info and Medline and database searches of combinations of the keywords “Obstructive Sleep Apnea”, “Adherence” and “Psychology/Psychological”. A particular focus in Table 1 is given to the strength and utility of psychological constructs derived from a sound theoretical and research basis. Strengths and limitations of each study are identified, as are the strength of the association between each variable or combination of variables with adherence. In developing a unified theory of CPAP adherence, an emphasis is given to previous research assessing constructs in the context of theoretical models of adherence, the use of prospective data collection and adequate sample sizes.

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TABLE 1 HERE

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Daytime sleepiness is a prevalent feature of the syndrome (ICSD-2, 2005). As presented in Table 1, Epworth Sleepiness Score (ESS; Johns, 1991), a measure of subjective sleepiness, is an inconsistent predictor of adherence across the literature. Some studies have found it to predict adherence (Engleman et al., 1996) and self-referrals for CPAP treatment (Hoy et al., 1999). Other studies report no effect of ESS score prior to treatment on determining CPAP adherence (Hui et al., 2001; Olsen et al., *in press*; Stepnowsky, Marler et al., 2002). However, subjective improvements in daytime and nocturnal symptoms with treatment, as demonstrated by an improvement in ESS score, may predict ongoing CPAP use (Engleman et al., 1996; Lewis et al., 2004; McFadyen, Espie, McArdle, Douglas & Engleman, 2001).

The degree to which patients report satisfaction with the treatment reliably correlates with adherence (Hui et al., 2001; Kribbs et al., 1993; Popescu et al., 2001). These subjective judgements of improvements in symptoms and daily functioning with treatment, as well as judgments about the severity of the associated side effects of the treatment, may

be associated with personality style. A recent study by Brostrom and colleagues (2007) indicated that characteristics of negative affectivity and social inhibition associated with “Type D” personality predicted greater reporting of side effects of the treatment, and subsequent poorer adherence.

Generally, the contribution of psychological predictors of adherence support a conceptualisation of adherence as a balance between the subjective benefits of using CPAP as reported by the patient, versus the costs of using it. From the patient’s perspective, the side effects of the treatment may be a sufficient “cost” of the treatment to outweigh the benefits of using the treatment.

#### *Psychological Symptoms and CPAP adherence*

Fewer symptoms of anxiety and depression at pre-treatment may be associated with better subsequent CPAP adherence (Edinger et al., 1994; Lewis et al., 2004). Edinger and colleagues (1994) administered the MMPI to 28 male OSA patients as well as measures of daytime sleepiness and sleep quality before they had experienced CPAP. At six months follow-up, 63% of the variance in self-reported use of CPAP was explained by a combination of the MMPI hypochondriasis and depression scales, as well as BMI, sleepiness and sleep quality. Self-reported nightly CPAP use, rather than objective CPAP machine hours, was the adherence measure in this study. As self-reported use is highly subjective, the conclusions able to be drawn from this study are limited. In addition, the direction of the effect is unclear (Andrews & Oei, 2004). It is unknown whether use of CPAP improves depressive symptoms, and this change predicts ongoing use, or alternatively, whether ongoing depressive symptoms with treatment impacts on subsequent adherence (Wells, Day, Carney, Freedland, & Duntley, 2004).

Stepnowsky, Bardwell and colleagues (2002) investigated the predictive value of psychological variables of pre-treatment anxiety, depression and coping variables in the

prediction of objective CPAP adherence. Twenty-three patients completed a psychological battery before experiencing CPAP, and adherence was measured at one week post-treatment initiation. They found that anxiety and depression did not correlate with CPAP adherence at one week. However, patients who used “active” ways of coping with life situations before starting treatment used CPAP more at follow up. “Active” coping refers to a tendency to use active means to manage difficult situations. This would include being open to modifying one’s lifestyle for the treatment.

The value of psychological variables, including anxiety and depression, in the prediction of CPAP adherence is currently unclear. However, this may be a reflection of the atheoretical and inconsistent ways in which these constructs have been investigated. Issues with acceptance of treatment are not uncommon in populations where individuals referred for treatment may have a low perceived need for treatment, for example, substance abusers. Within this framework, environmental, motivational and psychological factors have been identified as crucial to treatment acceptance (Katz et al., 2004; Satre, Knight, Dickson-Fuhrmann, & Jarvik, 2004).

#### *Social Support and CPAP adherence*

A large proportion of OSA patients are married or in long-term relationships (McFadyen et al., 2001; Stepnowsky, Marler et al., 2002; Wild, Engleman, Douglas, & Espie, 2004). Spousal support has been identified as a potential mediating variable relating to treatment adherence in other health domains (Doherty, Schrott, Metcalf, & Iasiello-Vailas, 1983; Jones, 2002). Of particular importance may be the spouse’s self-reported acceptance of a treatment (Doherty et al., 1983) and improvements in marital satisfaction with CPAP use (Kiely & McNicholas, 1997; McFadyen et al., 2001). More generally, partner support, relationship quality and self-efficacy have been found to be important predictors in cardiac patient’s compliance with rehabilitation (Jones, 2002). Consistent with

this, living alone has been identified as a potential predictor of poorer CPAP adherence (Lewis et al., 2004). The role of partner quality of life on CPAP adherence has not been addressed in previous research. Moreover, the role of marital satisfaction on CPAP adherence has only been addressed by one underpowered study (McFadyen et al., 2001). As such, the role of environmental factors such as social support and marital satisfaction on patient acceptance of CPAP treatment remains under researched.

### *Theoretical Models of CPAP Adherence*

A limited number of studies have investigated explicit psychological models of adherence derived from other health domains (Aloia et al., 2005; Olsen et al., *in press*; Sage et al., 2001; Stepnowsky, Marler et al., 2002; Wild et al., 2004; Wong, 2001). Prediction of CPAP adherence from a theory driven perspective has reduced some of the inconsistency noted in previous research. As outlined in Table 1, Stepnowsky, Marler et al., (2002) and Aloia et al., (2005) have applied Bandura's Social Cognitive Theory (SCT) (Bandura, 1998) and the Transtheoretical Model (TTM) (Grimley, Prochaska, Velicer, Blais, & DiClemente, 1994) to the prediction of CPAP adherence. Wild and colleagues (2004) utilised Wallston's Health Locus of Control and Social Learning Theory (SLT) (Wallston, 1992) to predict CPAP adherence before CPAP experience, while Olsen et al., (*in press*) and Sage and colleagues (2001) have applied constructs from the Health Beliefs Model (HBM) (Connor & Norman, 1996).

### *Social Cognitive Theory (SCT) and Transtheoretical Model (TTM)*

Bandura's SCT proposes that a patient's expectations for good or bad outcomes if the appropriate health behaviour is undertaken, and their belief in their ability to engage in the necessary behaviours to affect change (self-efficacy), are predictive of their subsequent engagement in these behaviours (Bandura, 1998; Britt, Hudson, & Blampied, 2004; Clark & Becker, 1998). SCT also emphasises the importance of knowledge and social support in

adherence (Stepnowsky, Marler et al., 2002). TTM proposes that a patient's readiness to engage in the required adherence behaviour ("readiness to change") is important for subsequent adherence (Prochaska, Johnson & Lee, 1998). Patients are conceptualised as moving through five stages of increasing readiness to change, from pre-contemplation (patient has no intention of engaging in the required health behaviour), contemplation, preparation (preparing to engage in the health behaviour within the next month), action and maintenance. Finally, the patients' subjective "weighing" of the pros and cons of the treatment (decisional balance) is also important in predicting adherence (Prochaska & DiClemente, 2005; Prochaska & Marcus, 1994). These models incorporate many aspects of the environmental, motivational and psychological factors identified in this review as important in predicting CPAP adherence. These include self-efficacy (Aloia et al., 2005; Sage et al., 2001), spousal support, and the patient's subjective weighing of the pros and cons of the treatment.

Stepnowsky, Marler and Ancoli-Isreal (2002) investigated SCT and TTM measures in predicting CPAP adherence at one-month post-CPAP fitting. They developed specific OSA measures assessing self-efficacy, outcome expectations, social support, knowledge and process of change and decisional balance. Significant relationships were found between the patient's decisional balance after 1 week of using CPAP and adherence at 1 month. This relationship was predictive even when CPAP pressure was statistically controlled. SCT measures of self-efficacy and outcome expectancies also predicted adherence. While the SCT constructs measured at 1 week explained an additional 26% of the variance in CPAP adherence, the four measures did not individually predict adherence. This may suggest that inter-correlations between the predictors, rather than unique contributions of the predictors themselves, were responsible for predicting adherence. Therefore, CPAP adherence must be

considered from a perspective of model building and testing, with clear predictions as to the complex interrelationships between predictors.

Aloia and colleagues (2005) found that readiness, self-efficacy and decisional balance, when measured at 1 week and three months after the patient had started CPAP, predicted CPAP adherence at 6 months. These constructs did not predict adherence when measured before experience with CPAP. That is, TTM and SCT predictors are not predictive in the initial stages of treatment, but become predictive as the patients' exposure to the therapy increased. Readiness and self-efficacy were the most predictive constructs, explaining approximately 23% of the variance in CPAP adherence. Contrary to the research of Stepnowsky, Marler and colleagues (2002), decisional balance was only predictive of adherence at 6 months when measured at 1 week after commencing on CPAP. When objective adherence was included in the prediction equation, the TTM and SCT constructs failed to explain any additional variance. This suggests that objective early adherence predicts subsequent adherence, with TTM and SCT constructs adding little to the picture. That is, these psychological variables are confounded by actual CPAP use, as they are not predictive before the patient has gained at least one week of exposure to the treatment.

Studies investigating the efficacy of TTM and SCT constructs in predicting CPAP adherence indicate that they add little variance above that explained by objective early adherence to the treatment. However, earlier research indicated that prediction of adherence *before* CPAP experience (treatment *acceptance*) using psychological variables is achievable (Edinger et al., 1994; McFadyen et al., 2001; Stepnowsky, Bardwell et al., 2002; Wild et al., 2004). This early prediction is vital, given that up to 30% of patients have already rejected the treatment before, or shortly after their titration study (Collard et al., 1997). Therefore, other models of adherence may be better able to explain why patients do not initiate or accept CPAP treatment (Olsen et al., *in press*). If psychological factors and



beliefs which impact on CPAP adherence are in place even before patient takes the device home, then the goal of treatment is to enhance patient acceptance of the treatment early in the assessment and treatment process, as well as support adherence later on.

### *Social Learning Theory*

Wallston's modified SLT emphasises that the patient's perception about the level of control they have over their illness will determine whether they change their behaviour to improve their health. Health Locus of Control is the central concept of this theory. This construct is subdivided into subscales of internality, powerful others and change. Patients who have a higher internal locus of control (i.e. they believe that they have control over their health) are more likely to adhere to treatment (Wallston, 1992; Wild et al., 2004). Patients with an external locus of control (i.e. they believe that their health is determined by external powerful others, such as a doctor, or is a matter of fate) will be less likely to adhere. The value one puts on their health (health value) is a moderator of the relationship between internal locus of control and health behaviour. That is, internal locus of control is only predictive of adherence when the patient values their health and their health outcome (Wallston, 1992). Finally, treatment specific self-efficacy, or the belief that one can effectively overcome obstacles to adherence, predicts adherence (Connor & Norman, 1996).

Wild and colleagues (2004) investigated SLT constructs of locus of control, generalised self-efficacy, and health value in 119 CPAP naïve OSA patients. It was found that general self-efficacy was not predictive of adherence at 3 months after commencing CPAP. In contrast, OSA disease specific variables of ESS, AHI, CPAP pressure and body mass index (BMI) predicted 18% of the variance in CPAP adherence. Internal locus of control as well as a lower belief in powerful others and more health value independently

predicted adherence. However, addition of the health locus of control and health value scales to the model only explained an additional 6% of the variance in adherence.

There are several methodological issues raised by Wild and colleagues' investigation of SLT. Although self-efficacy has been found to be a good predictor of adherence in other disorders (Connor & Norman, 1996; Jones, 2002), and is also predictive in other studies of OSA (Aloia et al., 2005; Sage et al., 2001), self-efficacy was not predictive in this study. However, a generalised self-efficacy measure was used for prediction. Research has shown that only a belief in ones ability to overcome barriers related to a specific treatment (treatment specific self-efficacy) is predictive of adherence to treatment (Connor & Norman, 1996). Therefore, Wallston's modified SLT has not yet been investigated strictly according to theory and remains a potentially useful model.

#### *The Health Belief Model*

The Health Belief Model (HBM) has been successfully applied to the prediction of compliance to several disease models (Clark & Becker, 1998; Connor & Norman, 1996; Juniper et al., 2004) and has been applied to CPAP adherence prediction (Olsen et al., in press; Sage et al., 2001). HBM allows for the inclusion of demographic, psychological and psychosocial influences on adherence (Connor & Norman, 1996). Although developed for the prediction of engaging in preventative health behaviours (such as wearing bicycle helmets; Quine, Rutter, & Arnold, 2000) the theory has been modified for specific illnesses.

According to HBM, the likelihood of engaging in health behaviour is based on readiness to act and expected benefit of the treatment. Readiness to act is determined by the patient's belief in their *susceptibility* to the illness consequences if they left their illness untreated, as well as the perceived *seriousness* of their illness. The patient's belief in the expected benefit of the treatment is based on their weighing of the perceived *benefits* to their health if they adhere to the treatment against the perceived *barriers* to action (Clark &

Becker, 1998; Connor & Norman, 1996; Quine et al., 2000). A *cue to action*, such as advice from a doctor, encouragement from the spouse, or a mass media campaign, acts as a trigger for the patient to commence healthy (adherence) behaviour (Quine et al., 2000). Self-efficacy (confidence) in being able to use the treatment in the face of barriers, where barriers may present as side effects or the expense of the treatment, cements motivation to commence and continue with the treatment (Connor & Norman, 1996; Quine et al., 2000).

In a prospective study of 40 Australian OSA patients, Sage and colleagues (2001) developed a CPAP questionnaire assessing HBM constructs. Patients completed the questionnaire after CPAP titration, and adherence was measured at one month follow-up. It was found that perceived benefits of using CPAP and the patients' belief in their ability to overcome obstacles to using CPAP (self-efficacy) were moderately positively correlated with CPAP adherence. Fewer concerns about barriers to using CPAP was also moderately correlated with CPAP adherence. Cues to action did not aid in the prediction of adherence. Overall, the HBM constructs of benefits and barriers were better predictors of CPAP adherence than the objective severity measures of RDI, BMI and CPAP pressure, explaining an additional 23% of the variance in adherence.

This initial finding lends some support to the use of HBM constructs in the prediction of CPAP adherence. These constructs were predictive after only one night of CPAP experience (the titration study), indicating that the model may be of use in the early prediction of CPAP acceptance and adherence. A small sample size and use of HBM measures which were not empirically validated limitations the generalisability of the study. These psychological constructs show potential in the prediction of adherence for OSA.

A further limitation of model testing in OSA to date is the use of simplistic, unidirectional regression models to predict relationships between psychological constructs and CPAP adherence. This approach overlooks the moderating and mediating relationships

between many of these variables. For example, the TTM constructs of readiness and decisional balance, as well as the SCT constructs of outcome expectations may be moderated by self-efficacy. That is, readiness may not be predictive of adherence when the patient lacks self-efficacy in being able to continue to use the treatment (Connor & Norman, 1996; Prochaska & Prochaska, 2004). These moderating relationships have not been addressed in studies previously applying psychological models to CPAP adherence. Rather, previous studies have successfully applied *measures* from these models in regression equations, but have not *tested* the models in a way that addresses the inter-relationships *between* these constructs.

#### *A New Model of CPAP Acceptance and Adherence*

Our research group has attempted to overcome the limitations of this previous research and utilise the HBM in prediction of both CPAP acceptance and adherence (Olsen et al., in press). We utilised a theoretically grounded, conceptual model of CPAP acceptance and adherence developed from HBM constructs. Figure 1 presents this new model.

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INSERT FIGURE 1 HERE

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The previous adherence literature available (see Table 1) indicates that biomedical and psychological variables (such as depression and anxiety) do not directly influence CPAP adherence. These constructs indirectly influence adherence by adding to the patient's perceived risk of negative health outcomes and the perceived severity of the disorder. This impacts on how the patient weighs the pros (benefits) and cons (barriers) of use, which in turn affects their acceptance of the treatment. HBM predictors of perceived risk, severity, benefits and barriers, in the presence of a cue to take action, directly predict acceptance of CPAP. The decision to accept CPAP as a treatment option then feeds back to inform the degree to which the patient perceives benefits and barriers to treatment, and their

confidence (self-efficacy) in being able to continue to adhere to the treatment. When combined with this feedback loop to the HBM constructs, CPAP acceptance will predict which patients continue to adhere to CPAP treatment at home. The basis of this model provides a foundation for informing the development of theoretically sound interventions for improving CPAP adherence.

Our initial validation study of this model (Olsen et al., in press) investigated HBM constructs in the prediction of CPAP adherence early in the treatment process. Patients were provided a psychological questionnaire after a diagnosis of OSA but prior to starting CPAP. Thus, they were naïve to the experience of actual physical side-effects of the treatment. CPAP adherence was measured at 4 month follow up. We hypothesised that patients would begin to develop expectations and beliefs regarding OSA and CPAP even before its use and before taking the treatment home from the hospital. We expected that patients who had already developed negative beliefs regarding the effectiveness of the treatment, undervalued the likely benefit they would experience in daily functioning with its use, as well as had low perceived disease severity would not fully accept the treatment from the outset and thus would be unlikely to adhere as recommended to the treatment in the long term. We utilised existing, validated, measures of constructs from the model including self-efficacy, perceived risk (susceptibility), functional outcomes (severity) and outcome expectancies (benefits).

Consistent with the HBM, we found that patient's expectancies regarding the effectiveness of the treatment (even prior to trying CPAP) predicted adherence at 4 months. Moreover, low perception of risk, and high perceived functional limitations due to sleepiness, such as in the areas of intimacy, activity levels and general productivity all uniquely predicted CPAP adherence. The HBM predictors explained 21.8% of the variance in CPAP adherence, whilst biomedical and HBM predictors together explained 31.8% of

variance in CPAP adherence. This supports previous research indicating that physiological measures of disease severity rarely independently predict more than 10% of the variance in CPAP adherence. Self-efficacy and psychological variables including depression, anxiety and stress did not directly predict CPAP adherence.

This initial validation of the HBM supports a call for early identification and support of patients with variables associated with low adherence, although there is still a great deal more work still needed in this area. The development and utilisation of validated measures to assess the model in its entirety are needed; namely, measures of barriers (side effects) and cues to action are required. Larger sample sizes, utilisation of moderated regression techniques and potentially the development of “cut-off” values to determine “clinically significant” changes in beliefs and expectations are clear directions for future assessment of the HBM in treatment acceptance and adherence.

#### *Psychological Interventions for Improving CPAP Adherence*

Psychological constructs are most powerful in predicting CPAP use, and a number of these constructs have the potential to be changed or modified. As CPAP modifications are now known to not improve adherence rates, resource allocation may be better targeted towards the identification of these modifiable, psychological predictors and then the development of interventions to specifically target them (Haniffa et al., 2004). Behavioural and cognitive behavioural interventions, as well as home support interventions and education have been used with this population (Aloia et al., 2004; Haniffa et al., 2004; Richards, Bartlett, Wong, Malouff, & Grunstein, 2007; Smith, Lang, Sullivan, & Warren, 2004). Table 2 presents studies investigating educational and behavioural interventions in adult OSA populations published to date, along with between group effect size estimates.

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INSERT TABLE 2 Here

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As demonstrated in Table 2, six education based interventions (Chervin, Theut, Bassetti, & Aldrich, 1997; Fletcher & Lockett, 1991; Golay et al., 2006; Hoy, Vennelle, Kingshott, Engleman & Douglas, 1999; Hui et al., 2000; Likar, Panciera, Erickson, & Rounds, 1997), and two Cognitive Behaviour therapy-based interventions (Aloia, Di Dio, Ilniczky, Perlis, Greenblatt, & Giles, 2001; Richards et al., 2007) have been reported in the literature.

Education-based interventions have not consistently demonstrated their efficacy in improving CPAP adherence, with effect size estimates between intervention and control groups ranging from 0.14 to 0.99. Many of these studies utilise small sample sizes and lack a time-matched control group. However, the larger, better controlled and representative studies of Hui and colleagues (2000) and Chervin et al., (1997), indicate that basic education provided early in the treatment process, may improve subsequent adherence rates. Specifically, these education programs involve providing information to new CPAP users about how to appropriately use CPAP, and how to overcome side effects related to treatment.

Hoy and colleagues (1999) reported 1.6 hours greater adherence for patients who received an additional CPAP titration night, education in their home which involved the partner, and regular follow-up visits for 4 months after treatment initiation compared to patients randomly assigned to standard CPAP support. The biggest effect size for change in CPAP adherence was noted by Chervin et al., (1997), who found that participants who received literature outlining the importance of regular CPAP use, used CPAP 2.7 hours more than a standard control group ( $d=.99$ ), and 1.4 hours more than a group who received weekly trouble-shooting phone calls.

The mechanisms by which changes in adherence behaviour occurs has not been directly tested. Education programs may increase patient self-efficacy in using the

treatment. They may also provide a vehicle for building patient's beliefs in the expected health benefit to be derived if the treatment is used. Without direct measures of these constructs, there remains little validation for patient education as a method of modifying patient beliefs and expectations as is required to sustain adherence to treatment in the long term.

Two studies have investigated the impact of Cognitive-Behaviourally and Motivational Interviewing orientated interventions on CPAP adherence, and compared these to standard care (Aloia and colleagues, 2001; Richards et al., 2007). As demonstrated in Table 2, large effect sizes of between 1.27 and 1.09 are demonstrated. Aloia and colleagues (2001) randomly assigned 12 OSA patients to either two sessions of brief instruction in the consequences of OSA and the efficacy of CPAP, or to a therapist time-matched standard care condition. There was no difference in adherence between the groups at weeks one or four after treatment initiation. However, by 12 weeks of treatment, the CBT group were using CPAP an average 3.2 hours longer than participants in the control group ( $d=1.27$ ). Moreover, despite a small sample size, which might account for the non-significant differences noted between the groups at 1 and 4 weeks follow-up, appropriate randomisation of groups and a therapist time-matched control was used.

Although presented as a cognitive-behaviourally based intervention, Aloia and colleagues (2001) describe a brief intervention more akin to Motivational Interviewing. In session 1 the advantages and disadvantages of the treatment, and pre-treatment PSG and other health symptoms are discussed before a goal for therapy is developed. Session 2 entails trouble-shooting, review of goals for treatment and development of realistic expectations with treatment. As with the education based treatments presented earlier, the mechanisms of change are not delineated, thus, the components of the treatment which affect the greatest change in patient beliefs and behaviour cannot be determined. It is



possible that education about the treatment is sufficient to improve adherence rates. Alternatively, the development of specific goals for use and promoting realistic expectations for treatment may be the powerful components. Additional research is required to determine theoretically stable and powerful treatment components from which to build an intervention to improve CPAP adherence.

Richards, Bartlett and colleagues (2007) also found a large effect size difference in treatment adherence in 50 patients who were randomly assigned to a group CBT intervention as compared to 50 patients who received treatment as usual ( $d=1.09$ ). CBT consisted of group sessions including the patient and their partner, and targeted the identification and modification of faulty beliefs regarding the treatment. Moreover, videos showing “role models” persevering with the treatment were presented. Simple relaxation strategies were utilised to minimise anxious reactions as the patients tried on their masks. Participants who completed the two, one hour CBT interventions used CPAP 2.9 hours more per night at 28 days after starting CPAP. In addition, the CBT group reported higher self-efficacy and social support. Without the addition of a therapist time-matched control group, and without controlling for partner involvement in both interventions, it is difficult to identify the precise mechanism of change in this study, although there is good evidence that self-efficacy and social support were important factors in patient use of CPAP at 28 days. The degree to which these changes persist in the long term is a target for future studies utilizing longer follow up time frames. This study represents the most rigorous study of this kind presented in the literature to date, and provides support for the use of psychological theory and intervention in targeting the problem of CPAP adherence.

In summary, psychological interventions used to improve adherence to CPAP have provided promising results. Methodological limitations associated with these need to be addressed in further research. Specifically, small sample sizes, and an atheoretical

application of these interventions leaves the specific process of change involved with these open to interpretation. However, the better controlled studies of Aloia et al., (2001), Hoy et al., (1999), Chervin et al., (1997) and Richards et al., (2007) indicate that interventions designed to target motivational aspects of treatment acceptance, such as developing specific goals for CPAP use and building self-efficacy and a sense of social support, have some theoretical and empirical support for the problem of CPAP adherence.

### *Motivational Interviewing*

Motivational Interviewing (MI) has gained recognition as an efficacious treatment for enhancing health behaviour for a variety of disorders, including reducing addictive behaviour such as smoking and alcohol dependence, and increasing treatment compliance (Burke, Arkowitz, & Menchola, 2003; Miller & Rollnick, 2002). MI is a client-centered therapy designed to enhance a patient's readiness to change, or in the case of CPAP adherence, readiness to initiate and adhere to treatment.

MI appears to be particularly relevant to the problem of CPAP adherence in OSA (Aloia et al., 2004) as it addresses the patient's ambivalence regarding CPAP use and is consistent with several models of the models of behaviour change (Britt et al., 2004) which have been applied to CPAP. These include Social Cognitive Theory and TTM (Aloia et al., 2005; Stepnowsky, Marler et al., 2002), Health Belief Model (HBM) (Sage et al., 2001) and SLT (Wild et al., 2004). All of these models share three constructs which provide the basis for MI. These constructs are; 1) the patient's outcome expectations for using the treatment; 2) the patient's belief in their ability to engage in the behaviour (self-efficacy); and 3) the patient's readiness to engage in the behaviour (Miller & Rollnick, 2002). The expected mechanism of change in this intervention is clear, precise and measurable. The use of MI with patients in the early phases of CPAP treatment shifts their focus from the negatives of the treatment to the positives of the treatment. This in turn theoretically increases their

motivation to *start* using CPAP, and continue using CPAP in the long term. Therefore, exploration of the efficacy of a CPAP specific MI intervention in improving CPAP adherence rates is both theoretically and practically sound.

#### *Directions for Future Research*

Psychological constructs and theory have a lot to offer the real problem of poor adherence in this very serious disorder. However, there remains large gaps and inconsistencies in the psychological literature. Table 3 presents the directions for research in the psychology of OSA identified in this review. First, the successful treatment of OSA is limited by suboptimal adherence rates to CPAP. However, there is limited validation for “optimal adherence” guidelines. The dosage of CPAP needed for effective treatment, beyond the assertion that better outcomes are achieved with more CPAP use is unclear. The critical treatment endpoints, whether decreased cardiac risk, decreased accidents at work or improved social functioning, need to be better explicated. In addition, while modifiable psychological and psychosocial predictors of CPAP adherence have gained some recognition in the literature, environmental factors such as social support and marital satisfaction are viable areas for improved quantitative research.

The application of robust theoretical models to OSA research has substantially improved our understanding of the role of psychological constructs in CPAP adherence. However, additional large scale studies investigating diverse OSA populations are needed to further validate these models. At present, SCT and HBM are demonstrating considerable promise in explaining the problem of CPAP adherence. Moreover, SLT and TTM have also been tested, and demonstrate some promise for CPAP prediction. Continuing research should move beyond the current regression approach to analyses. Moderating and mediating relationships between psychological predictors and constructs within these models have potential to explain additional important variance in CPAP adherence.

Sophisticated testing of these models through quantitative statistical modeling is required for these internal motivational processes to be adequately assessed.

The use of psychological and educational interventions for improving CPAP adherence is a largely understudied area of research, dominated by small, underpowered, studies with poor or highly variable methodologies. However, CBT-based interventions, as well as interventions designed to address the motivational aspects of CPAP use, such as Motivational Interviewing, can be directly tested through RCT's, and are suggested as appropriate interventions for this population.

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Figures

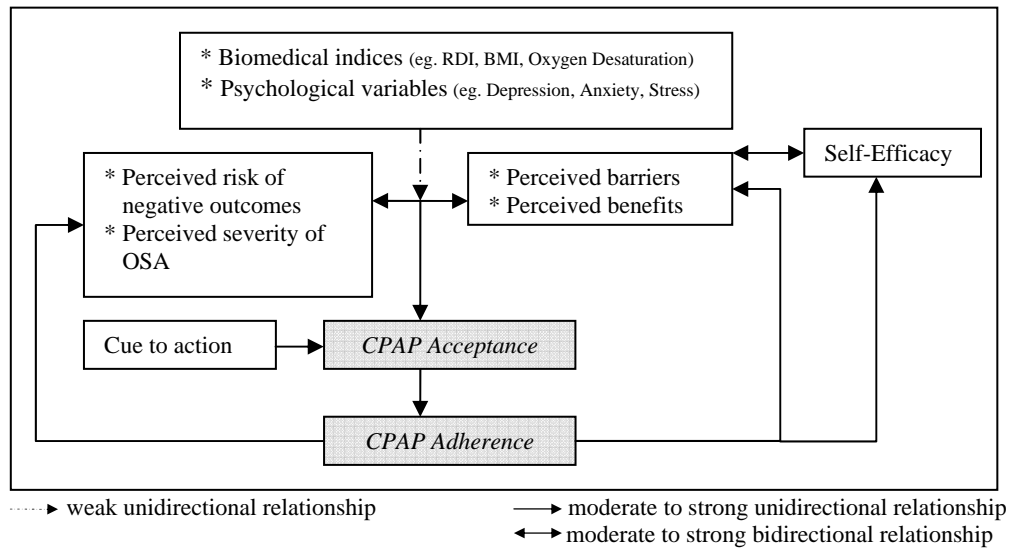


Figure 1. A conceptual model of CPAP acceptance and adherence (modified from Clark & Becker, 1998; Olsen, Smith, Oei & Douglas, in press)



Table 1: Psychological Predictors of CPAP use

| Study                 | Participants   | Methodology  | Outcomes   | Strength of Association   | Comments  |
|-----------------------|--|--|--|---|---|
| Aloia et al., 2005    | 98 (65 male)<br>mean age=51.4 years<br>mean education=14.6 years<br>mean AHI=39.8 events/hour<br>mean BMI=33.8 kg/m <sup>2</sup><br>mean CPAP pressure=10.2 cmH <sub>2</sub> O   | <b>Theory:</b> Measures of the TTM model and SCT model, including <i>readiness, decisional balance, and self-efficacy</i> .<br><b>Testing:</b> Psychological battery at <i>baseline</i> (after CPAP titration but before treatment initiation), <i>three months follow-up</i> , and <i>six months follow-up</i> .<br>70 participants also completed the battery at <i>1 week follow-up</i> | <i>Baseline:</i> Readiness, self-efficacy and decisional balance did not predict adherence at 6-months<br><i>1 week follow-up:</i> TTM/SCT measures predicted adherence. Readiness and self-efficacy most predictive.<br><i>3 month follow-up:</i> TTM/SCT measures predicted adherence.<br>Objective use explained 52% and 78% variance in 6 month adherence. TTM and SCT measures did not improve prediction above objective adherence | $R^2=.066$<br>$R^2=.232$<br>$R^2=.415$  | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> <li>Well defined constructs</li> </ul>   |
| Brostrom et al., 2007 | 247 (203 male)<br>74 “Type D personality”<br>173 “non-Type D personality”<br>mean age=60 years<br>mean AHI (Type D personality)= 50.8<br>mean AHI (non-Type D personality)= 47.1<br>mean ESS (Type D)= 11.7<br>mean ESS (non-Type D)= 12.0 | <b>Theory:</b> Measures of Type D (distressed) personality including <i>negative affectivity</i> and <i>social inhibition</i> .<br><b>Testing:</b> Questionnaire collecting demographic data, personality type, side effects and adherence to CPAP treatment posted to eligible patients who had been using CPAP more than 6 months.   | 30% of patients categorized as “Type D personality”<br>Type D personality reported significantly more side-effects with treatment<br>Adherence was significantly lower for Type D patients compared to patients without Type D   |   | <ul style="list-style-type: none"> <li>Cross-sectional study</li> <li>Good sample size</li> </ul>   |
| Drake et al., 2003    | 71 (43 male)<br>mean age=50.7  | <b>Testing:</b> 5-factor personality inventory completed during first clinic visit.<br>Mean follow-up period was 46.9 days (ranging between 1 and 2 months)  | Improved sleep quality between diagnostic and titration PSG associated with objective adherence.<br>Five factor personality inventory not predictive of adherence.   |   | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> <li>Good sample size</li> </ul>  |
| Edinger et al., 1994  | 38 male veterans<br>mean age=53<br>mean education=12.1 years<br>mean RDI= 42.9   | <b>Testing:</b> MMPI completed prior to CPAP experience<br>CPAP use at 6 month follow-up assessed<br>28 participants retained for analysis.  | Divided into “compliers” (N=20) and “non-compliers” (N=8).<br>Compliers had a higher BMI, lower subjective sleepiness, better sleep quality prior to treatment and lower depression and hypochondriasis scores.  | $R^2=.63$   | <ul style="list-style-type: none"> <li>Prospective study</li> <li>Self-reported use of CPAP used as adherence measure</li> <li>Small, specific sample</li> </ul>                        |
| Engleman et al., 1996 | 204 (187 male)<br>mean age=53<br>mean AHI=47   | <b>Testing:</b> Patients using CPAP for a minimum 2 weeks.<br>mean duration CPAP treatment=632 days (range=16 to 2921)   | Pre-treatment ESS<br>Post-CPAP ESS<br>Nuisance problems with CPAP use<br>Mask Problems<br>$\Delta$ daytime function<br>$\Delta$ nocturnal symptoms<br>$\Delta$ general functioning   | $r=.22^\dagger$<br>$r=-.18^\dagger$<br>$r=-.15^\dagger$<br>$r=.17^\dagger$<br>$r=.44^\dagger$<br>$r=.35^\dagger$<br>$r=.46^\dagger$ | <ul style="list-style-type: none"> <li>Cross-sectional study</li> <li>Self-reported use of CPAP used as adherence measure</li> <li>Limited psychological predictors assessed</li> </ul> |

| Study                  | Participants  | Methodology   | Outcomes   | Strength of Association   | Comments   |
|------------------------|---|---|--|---|--|
| Hui et al., 2001       | 112 (101 male)<br>mean age=45.6<br>mean BMI=29.3<br>mean AHI=48                       | <b>Testing:</b> Assessed on variables and adherence at 1 month and 3 months post treatment initiation.  | Expense, inconvenience and nasal blockage/dryness were the main concerns.<br><i>1 month follow-up</i><br><i>3 month follow-up</i>  | ESS $r = .02$<br>Education $r = .07$<br>Satisfaction with CPAP $r = .35$<br>ESS $r = .06$<br>$\Delta$ ESS $r = .1$<br>Education $r = .09$<br>Satisfaction $r = .15$ | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> </ul>   |
| Kjelsberg et al., 2005 | 178 (135 male)<br>mean age=55.5<br>mean BMI=31.1<br>mean AHI=29                       | <b>Testing:</b> Retrospective mail out of questionnaire   | Compliance defined at >3 nights use/week. Non-compliance predictive of symptoms of anxiety and depression.   |   | <ul style="list-style-type: none"> <li>Cross-sectional study</li> <li>Compliance based on <i>days</i> of use rather than <i>hours</i> per night</li> </ul> |
| Kribbs et al., 1993    | 35 (29 male)<br>mean age=46.2<br>mean BMI=39.5<br>mean RDI=65.1<br>mean pressure=12.9 | <b>Testing:</b> Pre- and post-treatment questionnaire assessing CPAP side effects and satisfaction with treatment   | Divided into “regular users” (N=16) and “irregular users” (N=19) ( $\geq 4$ hours on $\geq 70\%$ of days). Compliance associated with:<br>Daytime energy levels<br>Satisfaction with CPAP treatment<br>Regular users had:<br>More years of education<br>Higher daytime energy levels on CPAP treatment<br>Greater satisfaction with CPAP treatment   | $r = .39$<br>$r = .44$  | <ul style="list-style-type: none"> <li>Prospective study</li> <li>Small sample size</li> </ul>   |
| Lewis et al., 2004     | 70 (66 male)<br>mean age=51<br>mean BMI=35.5<br>mean AHI=25.1                         | <b>Testing:</b> Semi-structured interview and the Hospital Anxiety and Depression scale following titration (baseline). Followed for a median 31 days (range= 11-121 days). Participants who rejected CPAP following titration were excluded from analyses. | No baseline variable significantly associated with CPAP use at 1 month. <i>Change</i> in ESS and anxiety and depression symptoms from baseline did predict adherence<br>$\Delta$ ESS $r = -.38$<br>$\Delta$ Depression $r = -.38$<br>$\Delta$ Anxiety $r = -.30$<br>Division of participants into “compliers” ( $\geq 4$ hrs use) and “non-compliers”. Experiencing a recent life event, reporting initial problems with the treatment during titration, and living alone associated with poorer adherence |   | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> <li>Good sample size</li> </ul>   |

| Study                  | Participants  | Methodology  | Outcomes   | Strength of Association                  | Comments   |
|------------------------|---|--|--|--|--|
| McFadyen et al., 2001  | 44 CPAP users and their partner (34 male OSA patients)<br>mean age=49<br>mean AHI=46      | <b>Testing:</b> Completed questionnaires before titration (baseline) and 3-months post titration.<br>Patient questionnaires included marital satisfaction, general health/functional status, and sleep specific quality of life (FOSQ).<br>Partner questionnaire included marital satisfaction only  | Primary physiological variables, and psychological variables at baseline and follow-up not predictive of adherence<br>Change scores for psychosocial variables correlated with compliance, except for patient marital satisfaction.  | $r = .31$<br>$r = .57$<br>$r = -.46$     | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> </ul>   |
| Meurice et al., 1994   | 44 (39 male)<br>mean age=58<br>mean BMI=34.9<br>mean AHI=52<br>mean pressure=9.68         | <b>Testing:</b> Equipped with a standard mask following CPAP titration.<br>Followed for a mean 14 months after treatment (range=8-39 months).  | Patients divided into “compliant” (N=30) ( $\geq 5$ hrs) and non-compliant (N=14) groups. Compliers reported fewer side effects and were aware of the benefits of using CPAP.  |  | <ul style="list-style-type: none"> <li>Prospective study</li> <li>Small sample size</li> </ul>   |
| Olsen et al., in press | 77 (47 male)<br>mean age=55.25<br>mean BMI=35.11<br>mean RDI=38.36<br>mean pressure=11.68 | <b>Theory:</b> Measures of Health Beliefs Model (HBM) used to predict adherence at 4 months. CPAP questionnaire measured outcome expectancy with treatment, self-efficacy, functional outcomes of sleepiness, and perceived risk of negative health outcomes.<br><b>Testing:</b> Participants completed questionnaire before titration (naïve to CPAP). Followed up 4 months post-treatment initiation | Primary physiological variables, and psychological variables (depression, anxiety and stress) at baseline not predictive of adherence<br>Patient’s outcome expectancies prior to using CPAP, perception of risk, as well as perceived functional limitations due to sleepiness all uniquely predicted CPAP initiation and adherence<br>Use at 4 month follow up associated with:<br>Health Beliefs Model constructs alone<br>Health Beliefs Model constructs with biomedical indices | $R^2 = 21.8$<br>$R^2 = 31.8$             | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> <li>Sound theoretical basis and validated measures of constructs</li> <li>Adequate sample size</li> <li>Model yet to be fully assessed</li> </ul> |
| Popescu et al., 2001   | 209 (190 male)<br>mean age=51<br>mean AHI=38.1<br>mean BMI=34.6                           | <b>Testing:</b> 2 week trial of CPAP following titration. Satisfaction, problems with treatment and adherence assessed at end of trial. Followed for 12 months.  | Acceptance of CPAP associated with lower ESS at end of loan and greater subjective improvement in symptoms from pre to post trial.<br>Continued use at 12 months associated with lower ESS at end of loan and higher ratings of symptom improvement.<br>Use at one year weakly associated with:  | $r = .299$<br>$r = -.299$<br>$r = -.201$ | <ul style="list-style-type: none"> <li>Well controlled, prospective study</li> </ul>   |

|                                   |  |   |  |  |   |
|-----------------------------------|--|---|--|--|---|
| Sage et al., 2001                 | 40 (30 male)<br>mean age=54.13   | <p><b>Theory:</b> Measures of Health Beliefs Model (HBM) and treatment specific Self-efficacy used to predict adherence at 1 month. CPAP questionnaire measured susceptibility, barriers, cues to change (symptom severity etc) and self-efficacy.</p> <p><b>Testing:</b> Participants completed questionnaire after they had undergone education for CPAP use, and given CPAP machine.</p> | <p>Psychological variables better predictors than objective severity measures (RDI, BMI &amp; CPAP pressure).</p>  | <p>Susceptibility <math>r = .10</math><br/>                 Severity <math>r = .15</math><br/>                 Benefits <math>r = .32</math><br/>                 Barriers <math>r = -.35</math><br/>                 Self-efficacy <math>r = .44</math></p>   | <ul style="list-style-type: none"> <li>• Prospective study</li> <li>• Small sample size</li> <li>• Measures used to assess HBM constructs not empirically validated</li> </ul>  |
| Stepnowsky, Bardwell et al., 2002 | 23 (16 male)<br>mean age=47.1<br>mean BMI=32.6<br>mean RDI=54.2<br>mean pressure= 10.2 | <p><b>Theory:</b> Used coping variables as predictors of adherence.</p> <p><b>Testing:</b> Before experience with CPAP, patients completed the Ways of Coping Questionnaire and Berkman Social Support Scale, as well as the CES-D, POMS, BD, CM, STA and ESS. Adherence measured at the end of the first week of treatment.</p>  | <p>Relationship between ESS and RDI with adherence not significant.<br/>                 Addition of Ways of Coping improved prediction.</p>   | <p>Depression <math>r = -.017</math><br/>                 Anxiety <math>r = -.181</math><br/>                 Stress <math>r = -.004</math><br/>                 Berkman Social Support <math>r = -.031</math><br/>                 BD <math>r = .129</math><br/>                 Ways of Coping <math>r = .607</math></p> | <ul style="list-style-type: none"> <li>• Prospective study, sound methodology</li> <li>• Small sample size</li> </ul>   |
| Stepnowsky, Marler et al., 2002   | 51 (49 male)<br>mean age=54.1<br>mean=36.4<br>mean=40.4<br>mean pressure=9.1           | <p><b>Theory:</b> SCT (self-efficacy, outcome expectations, social support and knowledge) and TTM (processes of change and decisional balance index) scales developed for study.</p> <p><b>Testing:</b> Questionnaires completed at CPAP fitting (baseline), 1 week post treatment initiation, and 1 month post initiation.</p>   | <p><i>Baseline</i><br/>                 SCT and TTM models, when controlling for CPAP pressure, did not significantly predict adherence.</p> <p><i>1 week follow-up</i><br/>                 CPAP pressure and ESS did not significantly predict adherence.<br/>                 Addition of SCT model improved overall prediction</p> <p><i>1 month follow-up</i><br/>                 Addition of TTM (decisional balance) to CPAP pressure and ESS improved prediction.<br/>                 Controlling for CPAP pressure, SCT model significant<br/>                 Relationship between TTM and adherence significant at 1 month.<br/>                 Decisional Balance best predictor of adherence</p> | <p><math>R^2_{adj} = .048</math><br/> <math>R^2_{adj} = .309</math><br/> <math>R^2_{adj} = .240</math><br/> <math>R^2_{adj} = .40</math><br/> <math>R^2_{adj} = .33</math></p>   | <ul style="list-style-type: none"> <li>• Well controlled, prospective study</li> <li>• Sound theoretical basis and validated measures of constructs</li> <li>• Only a veteran population used</li> <li>• More male participants than is usually represented in an OSA population</li> </ul> |

|                   |  |  |   |  |
|-------------------|--|--|---|--|
| Wild et al., 2004 | 119 (94 male)<br>mean age=51<br>mean BMI=33<br>mean AHI=45<br>mean pressure=9<br>mean ESS=13 | <b>Theory:</b> Measures from Wallston's SLT (MHLC, Health Value scale and GSES).<br><b>Testing:</b> Questionnaire completed <u>before</u> CPAP titration. Adherence measured at 3 months post treatment initiation | Logistic regression comprising clinical variables (AHI, ESS, BMI & CPAP pressure) and psychological variables (MHLC and health value. GSES not included in model).<br>Clinical predictors in model only: $R^2=.18$<br>Clinical predictors with psychological variables did not substantially improve prediction. $R^2=.24$<br>Health value the only psychological variable to significantly contribute. | <ul style="list-style-type: none"> <li>• Well controlled, prospective study</li> <li>• Psychological testing based on sound theoretical basis</li> </ul> |
|-------------------|--|--|---|--|

**Key:**  $\Delta$ = Change; †=rank correlations **BD:** Buss-Durkee Hostility Scale; **CES-D:** Center for Epidemiological Studies- Depression scale; **CM:** Cook-Medley Hostility Scale; **ESS:** Epworth Sleepiness Scale; **FOSQ:** Functional Outcomes of Sleep Questionnaire; **GSES:** Generalised Self-efficacy Scale; **MHLC:** Multidimensional Health Locus of Control Scale; **MMPI:** Minnesota Multiphasic Personality Inventory; **POMS:** Profile of Mood States; **RDI:** Respiratory Disturbance Index; **SCT:** Social Cognitive Theory; **SLT:** Social Learning Theory; **STA:** Spielberger Trait Anxiety Scale; **TTM:** Transtheoretical Model.

Table 2: Educational/Behavioural Interventions for increasing CPAP use

| Study                    | Participants   | Methodology   | Outcomes  | Strength of Effect                                | Comments  |
|--------------------------|--|---|---|---|---|
| Aloia et al., 2001       | 12<br>mean age=65.5<br>mean AHI=43.5   | Randomly assigned to groups (stratified by age, education, disease severity and vigilance).<br>Group 1 (N=6) <i>cognitive-behavioural intervention</i> : two 45-minute sessions educating patients on illness consequences and the efficacy of CPAP.<br>Group 2 (N=6): <i>standard therapist time-matched control</i> with no education about OSA or CPAP.<br>Adherence measured at 1, 4, and 12 weeks post treatment initiation. | <i>Week 1</i><br>Mean use in CBT=5.2 hr/night<br>Mean use in standard support=5.2 hr/night<br><i>Week 4</i><br>Mean use CBT=6.3<br>Mean use control=5.0 (difference not significant).<br><i>Week 12</i><br>Mean use CBT=7.8<br>Mean use control=4.6 (significant difference). | d=0.30<br><br>d=0.56<br><br>d=1.27                | <ul style="list-style-type: none"> <li>• Brief CBT focussed intervention effective by week 12.</li> <li>• Small sample size.</li> <li>• Good methodology, time-matched control group.</li> </ul>  |
| Chervin et al., 1997     | 33 (21 male)<br>mean age=51.7<br>10 patients were newly diagnosed with OSA.<br>12 patients were continuing CPAP users.                                       | Randomly assigned to groups.<br>Group 1 (N=12) <i>telephone support</i> : one telephone call per week asking about problems and encouraging nightly use.<br>Group 2 (N=14) <i>literature intervention</i> : fact sheet about OSA and snoring and guidelines for CPAP use.<br>Group 3 (N=7): <i>no additional intervention</i><br>Contacted 1 and 2 months post intervention.  | Mean use in literature=7.1<br>Mean use in telephone support =5.7<br>Mean use in control group =4.4<br>Mean use continuing patients=6.29<br>Mean use new patients=5.88 (difference not significant).   | (compared to control group)<br>d=.99<br><br>d=.45 | <ul style="list-style-type: none"> <li>• Education focussed intervention effective.</li> <li>• Intervention more beneficial for patients with lower education.</li> <li>• Small sample size.</li> <li>• No measure of treatment integrity.</li> <li>• Half of the sample were continuing patients.</li> </ul> |
| Fletcher & Luckett, 1991 | 7 male<br>mean age=51.6<br>mean AI=49  | Alternating assignment to telephone reinforcement group or control.<br>After 3 months, groups swapped.<br>Group 1 <i>telephone reinforcement</i> : called weekly for 3wks, then monthly for 2 months. Talked about severity of disease, complications of apnea, benefits of nCPAP and suggestions for minimising side effects.<br>Group 2 <i>control</i> : called once per month for check up on mechanical problems etc.         | Mean use reinforcement period =5.95<br>Mean use non-reinforcement period =6.04  |   | <ul style="list-style-type: none"> <li>• Education based intervention not effective.</li> <li>• Small sample size</li> <li>• No random assignment to groups</li> </ul>  |
| Golay et al., 2006       | 35 (22 male)<br>mean age=58.3<br>mean BMI=34.9<br>mean AHI=49.7<br>mean CPAP pressure=8.6<br><br>Mean length of time using CPAP before intervention=323 days | Patients were enrolled in an inpatient group program targeting benefits of using CPAP, inconveniences associated with CPAP and practice with use of the machine   | Mean use at Baseline=4.4<br>Mean use 3 months after program=5.1   |   | <ul style="list-style-type: none"> <li>• Group based education program effective</li> <li>• Small sample size</li> <li>• No random assignment to groups</li> </ul>  |
| Hoy et al., 1999         | 80 (78 male)<br>mean age=51<br>mean BMI=33<br>mean AHI=58  | Randomly assigned to groups.<br>Group 1 <i>standard CPAP support</i><br>Group 2 <i>intensive support</i> : included usual support plus 2 extra nights of titration (total=3), education in patient's home involving partner, home visits by nurses at 7, 14, 28 days and 4 months after initiation.<br>Adherence measured at 6 months   | Mean use Intensive Support = 5.4<br>Mean use Standard Support= 3.8.<br>40% improvement in adherence continued at 6 months.  | d=0.67  | <ul style="list-style-type: none"> <li>• Education based intervention effective.</li> <li>• Good sample size and methodology</li> <li>• No time-matched control group</li> </ul>  |

| Study                 | Participants  | Methodology  | Outcomes   | Strength of Effect | Comments   |
|-----------------------|---|--|--|--------------------|--|
| Hui et al., 2000      | 108 (97 male)<br>mean age=45<br>mean BMI=30<br>mean AHI=48  | Randomly assigned to groups.<br>Group 1 <i>Basic CPAP education</i> : mask fitting and short CPAP trial. Followed-up at 1 and 3 months.<br>Group 2 <i>Augmented Support</i> : Basic education+ extra education about OSA and CPAP via 15 min video. Nurses followed-up by telephone on days 1 and 2, and on weeks 1, 2, 3, 4, 8 and 12.  | <i>1 month</i><br>Mean use Augmented=5.5<br>Mean use Basic =5.3 (difference not significant)<br>No difference at 3 months.<br>Greater Quality of Life improvement in Augmented Support group at 1 and 3 month follow-up. | d=.14              | <ul style="list-style-type: none"> <li>• Augmented education based intervention not additionally effective than basic education.</li> <li>• Good sample size and methodology.</li> </ul>                                   |
| Likar et al., 1997    | 34 male<br>mean age=58<br>mean BMI=37<br>mean AHI =34<br>mean CPAP pressure =12<br><br>Mean length of time using CPAP before intervention=463 days. | Evaluation of standard care group education sessions.<br>8 to 10 patients per 2 hour session (afternoon) scheduled every six months.<br>Session involved:<br>Pulmonary care nurse instruction on OSA diagnosis, CPAP use and cleaning. Videotape on assembly, cleaning, adjustments and accessories for the CPAP machine. Encouraged to ask questions and compare experiences. | Mean use after first clinic increased from 5.2 to 6.3 hr/ night<br>29% of patients increased use by 2 hr/ night<br>6% decreased use by 2 hr/night<br>Results sustained over 3 years.                                     |                    | <ul style="list-style-type: none"> <li>• Education based intervention effective.</li> <li>• Retrospective Chart Review.</li> <li>• No Control group.</li> <li>• Did not control for number of clinics attended.</li> </ul> |
| Richards et al., 2007 | 100 (96 male)<br>mean age=56<br>mean BMI= 30<br>mean RDI= 25 (CBT group), 27 (TAU)<br>mean ESS= 10  | Randomly assigned to TAU (50) or CBT group (50)<br><i>CBT intervention</i> : components of SCT (increased perceived self-efficacy, outcome expectations, and social support). Involved 2 one-hour sessions spaced 1 week apart with 10 participants and their partners in each session   | <i>28 days</i><br>Mean use CBT=5.38<br>Mean use TAU=2.51   | d=1.09             | <ul style="list-style-type: none"> <li>• Brief Cognitive and Behavioural Intervention including partner was effective</li> <li>• Good sample size and methodology</li> <li>• No time-matched control group</li> </ul>      |

**Key:**

**CBT:** Cognitive Behavior Therapy; **SCT:** Social Cognitive Theory; **TAU:** Treatment as Usual

*Table 3. Directions for Future Research*

1. Dosing guidelines for objectively defining *optimal* CPAP adherence
2. Role of partner support and general social support in CPAP adherence
3. Further investigation of psychological models of CPAP adherence
4. Further Randomised Control Trials of theory driven psychological interventions for improving CPAP adherence