MU Sinclair School of Nursing
University of Missouri

MASTER’S EXAMINATION

Cover Sheet
(This cover/face sheet must be attached to your examination when you submit it.)

School of Nursing Assigned ME Number: FS2011-1322

My area of specialization is: Family Nurse Practitioner

The problem, within my area of specialization, which I have addressed, is: Adherence to continuous positive airway pressure for the treatment of obstructive sleep apnea.

I would suggest the faculty readers listed below. The MS exam committee assigns the readings of examinations to faculty on the basis of availability and/or appropriateness of readers. The committee cannot guarantee that your examination will be assigned to faculty you list.

- Erin Kilburn
- Sara Revelle
- Pam Evans-Smith
- Tina Bloom
- Lori Popejoy

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Continuous Positive Airway Pressure Adherence

University of Missouri – Columbia

September 30, 2011

FS2011- 1322
Abstract

Obstructive sleep apnea (OSA) is a form of sleep disordered breathing characterized by episodes of apnea and hypopnea, which result in a decreased quality of life, cardiovascular consequences, increased risk for motor vehicle and occupational accidents, and increased healthcare utilization. Continuous positive airway pressure (CPAP) is the therapy of choice, though acceptance and adherence to therapy is generally poor. This review of the literature seeks to understand the facilitators of and barriers to CPAP acceptance and adherence in order to guide future research in this area and effectively promote CPAP adherence.
Continuous Positive Airway Pressure Adherence

OSA is a form of sleep disordered breathing resulting in oxyhemoglobin desaturation and sleep fragmentation (Weaver & Sawyer, 2010). The prevalence of mild OSA may be as high as 9% in women and 24% in men (Rosenberg & Doghramji, 2009). Untreated, OSA has significant cardiovascular and neurocognitive consequences resulting in a sevenfold risk for motor vehicle accident (C. E. Smith, Dauz, Clements, Werkowitch, & Whitman, 2009). Sleepiness related motor vehicle and occupational accidents is estimated at $56 billion annually in the United States (Gottlieb et al., 1999). The World Health Organization (n.d.) indicates that the cost of healthcare utilization for patients with OSA was twice that of their healthy counterparts prior to treatment. Therefore, identifying patients with OSA and promoting adherence to therapy is imperative.

The purpose of this literature review is to determine the factors that influence CPAP use in order to effectively increase adherence to treatment and identify future directions for research related to this topic. In order to more fully understand the topic of OSA and CPAP adherence, explanations of the disease and treatment are provided.

**OSA.** OSA occurs when repeated apneic (>10 seconds) and hypopneic (desaturations 3% below patient’s awake level) episodes stimulate the sympathetic nervous system (C. E. Smith, et al., 2009). Characteristics and risk factors for OSA are increased neck circumference (>17 inches in males, and >16 inches in females), BMI ≥ 30 kg/m², and certain anatomical features of the nose and jaw (which may require alternative treatment), and patients with existing congestive heart failure, atrial
fibrillation, and treatment refractory hypertension (Epstein et al., 2009). Patients suspected of having OSA undergo an overnight polysomnography to diagnose and confirm need for therapy as well as optimal pressure settings for CPAP (Damjanovic et al., 2009).

Severity of OSA has classically been defined by the apnea-hypopnea index (AHI) or number of apneic or hypopneic episodes occurring hourly (Sawyer et al., 2010). AHI ≥ 5 in conjunction with daytime sleepiness, loud snoring, witnessed breathing interruptions, or awaking due to gasping or choking, and AHI ≥ 15 without symptoms are diagnostic of OSA (Epstein, et al., 2009). AHI increases with severity of OSA, regardless of symptoms, and may in fact poorly correlate with symptoms (Epstein, et al., 2009; Stepnowsky, Palau, Marler, & Gifford, 2007)

**CPAP.** CPAP is the gold standard for treatment of OSA, though adherence to therapy is generally poor (Olsen, Smith, & Oei, 2008). CPAP pneumatically splints the upper airway subsequently decreasing the AHI (Epstein, et al., 2009). Typically, CPAP is initiated during the polysomnography (an overnight sleep study) and is titrated to abolish apneas and hypopneas (Richards, Bartlett, Wong, Malouff, & Grunstein, 2007).

Though CPAP is generally the therapy of choice for OSA, an estimated 20-30% of patients quit therapy within 2 weeks and another 20-30% quit by 6 months, with a reported 50% failing to use CPAP at optimal levels thereafter (Sawyer, Canamucio, et al., 2010; C. E. Smith, et al., 2009). Although cost effectiveness of treatment has not been adequately assessed, a position statement of the American Academy of Sleep Medicine (AASM) justifies the cost of treating OSA with CPAP ("Cost justification for

**Search methods.** For the purpose of this literature review, a search was conducted across the following databases: Cumulative Index to Nursing and Allied Health Literature, PsychINFO, PubMed, and MEDLINE (Ovid). Keywords and combinations of these words included: (a) continuous positive airway pressure, (b) CPAP, adherence, (c) compliance, (d) education, (e) intervention, (f) cost, (g) economic. This search was refined to look for articles in English within the last 5 years, with the exception of two classic studies (Gottlieb, et al., 1999; Hoy, Vennelle, Kingshott, Engleman, & Douglas, 1999) and a meta-analysis (Patel, White, Malhotra, Stanchina, & Ayas, 2003) which add depth to this topic. Special attention was given to randomized controlled trials, systematic reviews, and meta-analyses. In addition, the reference lists of studies were searched by hand to identify any other possible studies which may enhance knowledge of this topic.

Inclusion and exclusion criteria were important in order to obtain a more homogeneous mixture of studies relevant to the topic of OSA and CPAP adherence. Studies in this review included those that discussed OSA and CPAP adherence (or lack thereof) in adults aged 18 years or older. Studies including other forms of positive airway pressure (PAP), such as Bilevel PAP, and auto-titrating PAP were used if the focus was on therapy adherence. Studies excluded from this review were those that focused on central apnea, children, and treatments other than PAP. Some of these treatments were surgical correction of facial structures, gastric surgeries to reduce obesity, appliances worn at night to open the pharynx and medications. This review
shall be organized in terms of facilitators of CPAP adherence and barriers to CPAP adherence.

**Review of Literature**

**CPAP adherence**

CPAP adherence has been loosely defined as four hours per night on 70% of nights (Sawyer et al., 2011). However, this benchmark has only recently been substantiated by a study investigating CPAP use and normalization of sleepiness and functioning (Weaver et al., 2007). This study determined that there is a dose-response effect with CPAP and sleepiness and functional outcomes; meaning that increased use resulted in improved outcomes with four hours of use being the very least that improved these outcomes (Weaver, et al., 2007).

Recently this benchmark definition of adherence has carried more weight. In November 2008, the Centers for Medicare and Medicaid (CMS, 2008) applied this definition of adherence (four hours on 70% of nights) to 30 consecutive days within the first three months of treatment (Aloia, Knoepke, & Lee-Chiong, 2010). If a patient fails to meet this level of compliance, treatment will be deemed medically unnecessary and the patient will have to be reevaluated (by polysomnography) in order to qualify for coverage of a CPAP device (Aloia, et al., 2010; Centers for Medicare and Medicaid, 2008).

Prevalent throughout the literature is the notion that one single factor alone cannot predict acceptance and adherence to CPAP (Kohler, Smith, Tippett, & Stradling, 2010; Poulet et al., 2009; Weaver & Sawyer, 2010). However, it is apparent from the
literature that certain factors, intrinsic and extrinsic, act as facilitators and barriers to CPAP adherence. In the next few sections studies are explored for their relationship to CPAP adherence in terms of facilitators and barriers.

**Facilitators of CPAP Adherence**

Factors influencing CPAP adherence include, but are not limited to: (a) initial experience with CPAP, (b) interventions promoting CPAP adherence, (c) psychological factors, (d) improvement, (e) self-efficacy and (f) significant others.

**Initial experience with CPAP.** Despite the effectiveness, many reject CPAP before initiation or shortly thereafter (Wolkove, Baltzan, Kamel, Dabrusin, & Palayew, 2008). Individualization and optimizing comfort of apparatus are undisputedly initial first steps in promoting CPAP acceptance (Damjanovic, et al., 2009; Weaver & Sawyer, 2010). In addition, adherence patterns are established within the first few days of therapy and are a powerful predictor of long-term adherence (Budhiraja et al., 2007; Richards, et al., 2007; Sparrow, Aloia, Demolles, & Gottlieb, 2010; Stepnowsky, Palau, Marler, et al., 2007). In fact, one study concludes that a low level of adherence at two weeks should be considered a relative discontinuation of CPAP (Aloia et al., 2007). In a concurrent, mixed method, descriptive study, adherent participants tended to have a positive response to the titration study, which inspired their commitment to treatment even when faced with barriers (Sawyer, Deatrick, Kuna, & Weaver, 2010). This same study determined that initial experiences were important for every participant (Sawyer, Deatrick, et al., 2010).

**Interventions to promote CPAP adherence.** The decision to continue therapy is made early in the treatment period (<1 week of therapy) and this decision may be
influenced by interventions which may include (a) education and support, (b) cognitive behavioral therapy (CBT), (c) and motivational techniques (Olsen, et al., 2008; Sawyer, Canamucio, et al., 2010) Indeed many studies exist to enhance and evaluate CPAP adherence, however a balance must be achieved between cost of therapy, clinical applicability and efficacy of the intervention. Interventions designed to promote adherence are prevalent throughout the literature. Below is an overview of the intervention literature with types of interventions as subheadings.

**Education and/or support.** Perhaps the most plentiful of interventions are those that seek to improve adherence through education and/or support. For the purpose of this review, education and/or support interventions will be defined as those that provide one or both of these types of interventions and provide more than the usual care. One classic randomized controlled, parallel group study by Hoy (1999), provided education and support through a video, telephone calls and follow-up home visits. In spite of significant improvement in adherence, the cost of care (approximately $1500 per person) may outweigh the benefit (Hoy, et al., 1999).

Later studies took cost into account. A randomized, controlled trial (RCT) evaluating education combined with a habit-forming, musical audiotape, was effective in promoting adherence at one month (C. E. Smith, et al., 2009). Another pilot (RCT) utilized tele-monitoring of CPAP use to collaboratively determine a plan for improved adherence (Stepnowsky, Palau, Marler, et al., 2007). Though the study was too underpowered to show significance, the group allocated to receive intensive support appeared to be more adherent at one month (Stepnowsky, Palau, Marler, et al., 2007).
In a French study evaluating prescriber and homecare education, those who received reinforced education by both were more likely to adhere to treatment (Meurice et al., 2007). A similar RCT comparing standard care or intensive support and CPAP or auto-titrating positive airway pressure found that the intensive support group and CPAP were more adherent at nine months (Damjanovic, et al., 2009). In addition, those who were intensively supported were more likely to follow-up; a theme present in another study evaluating follow-up rates (Damjanovic, et al., 2009; Lewis, Bartle, Watkins, Seale, & Ebden, 2006). However, this educational effect weakened over time possibly demonstrating the need for education and support throughout treatment (Lewis, et al., 2006).

A session of education in patients already using CPAP may be the answer to this problem. In a large, non-randomized study, participants were offered one 120 minute lecture presentation on CPAP use and benefits, however subjective reporting of CPAP use and lecture attendance potentially limited accuracy of results (Fuchs, Pittarelli, Hahn, & Ficker, 2010). Another study evaluated the unique concept of positive or negative educational message framing in a brief weekly phone call (Trupp, Corwin, Ahijevych, & Nygren, 2011). This study determined that emphasizing the negative aspects of the chronic disease of OSA may enhance CPAP adherence (Trupp, et al., 2011).

The concept of education and support in CPAP adherence intervention literature is not new. The interventions, however, are diverse in the design, method, and population. Education and support may help tip the scales in the direction of better
adherence for OSA patients. Theories, however, are gaining momentum as the basis for interventions to promote adherence.

**CBT.** Indeed, CBT works by influencing perceptions of CPAP to improve adherence (Sawyer, et al., 2011; l. Smith, Nadig, & Lasserson, 2009). In a recent study, CBT participation was associated with a significantly higher CPAP use at one month versus usual care consisting of education (Richards, et al., 2007). Another RCT utilized CBT via telemedicine to influence CPAP use (Taylor, Eliasson, Andra, Kristo, & Howard, 2006). Results, however, were disappointing because the time spent on the telephone with the intervention group was balanced by increased impromptu clinic visits by the control group (Taylor, et al., 2006). Another study examined the use of education on psychological constructs described in the Social Cognitive Theory (Sawyer, Canamucio, et al., 2010). Researchers found that risk perception and treatment expectancies after education may predict CPAP use at four months (Sawyer, Canamucio, et al., 2010). Weaver & Sawyer (2010) concur that CBT may be more effective in conjunction with education and social support.

**Motivational interviewing.** In recent literature, motivational enhancement therapy or motivational interviewing has become increasingly utilized and potentially efficacious (Olsen, et al., 2008). Motivational interviewing, which is theoretically based in Social Cognitive Theory and the Transtheoretical Model, is a client-centered therapy which addresses readiness to change and ambivalence toward treatment (Aloia, et al., 2007; Olsen, et al., 2008; Sparrow, et al., 2010). A recent RCT (with a placebo control for attention) examining motivational interviewing over the phone showed a 30% increase in CPAP use over a 12 month period (Sparrow, et al., 2010). Another RCT with
142 participants, involving motivational interviewing found it to be as effective as education on improving CPAP adherence at 13 weeks (Aloia, et al., 2007). One underpowered study involving mainly low-income, African American women showed a trend toward improved CPAP especially at two weeks (Roecklein et al., 2010). As is congruent with Aloia et al. (2007), CPAP use at two weeks predicted use at three months (Roecklein, et al., 2010).

**Theoretical basis for interventions.** Theory was evident in literature pertaining to interventions to improve adherence. The most widely used theory found in the literature was Bandura’s Social Cognitive Theory (Richards, et al., 2007; Taylor, et al., 2006). This theory translates into cognitive behavioral therapies, which attempt to affect behavior with new knowledge (Richards, et al., 2007). Motivational enhancement therapy is based on Social Cognitive Theory combined with the Transtheoretical Model and is used as the basis for intervention in two studies (Aloia, et al., 2007; Roecklein, et al., 2010). The Transtheoretical Model recognizes that a person weighs the pros and cons of a decision and takes into account readiness to change (Sawyer, Canamucio, et al., 2010). Other theories found in the intervention literature include the Health Belief Model (Sawyer, Canamucio, et al., 2010), Prospect Theory (Trupp, et al., 2011), and the Triandis Theory of Behavior (C. E. Smith, et al., 2009).

**Psychological factors.** Patients who were able to view OSA in terms of their own health status and relate their condition to the disease were more likely to be adherent in a descriptive, longitudinal study by Sawyer, Deatrick et al. (2010). In this same study, outcome expectancies with respect to symptom improvement, also contributed to better adherence (Sawyer, Deatrick, et al., 2010). Although it is well
established that there is a high rate of CPAP nonadherence, there is a striking
dichotomy (10-20%) of patients who simply cannot do without therapy (Poulet, et al.,
2009; Wolkove, et al., 2008).

Another descriptive, explorative study of 23 individuals found that putative
factors, such as avoiding OSA symptoms, knowledge of the risk for medical
consequences, fear of negative social consequences and disturbing the sleep of others
were facilitators of therapy adherence (A. Brostrom et al., 2010). Unique to this Swedish
study, was the participants risk of losing their driver’s license if OSA remained untreated
(A. Brostrom, et al., 2010). Positive facilitators of adherence were positive descriptions
of CPAP by others, low rental costs for CPAP, the belief in a positive effect of therapy,
and self-efficacy in managing treatment (A. Brostrom, et al., 2010).

Improvement. Though adherence has been reported to significantly improve
subjective symptoms, primarily daytime sleepiness, the evidence is conflicting (Gottlieb,
et al., 1999; Richards, et al., 2007; I. Smith, et al., 2009; Sparrow, et al., 2010; Weaver
& Sawyer, 2010). Interestingly, subjective sleepiness (as measured by Epworth
Sleepiness Scale) and objective sleepiness (as measured by the Maintenance of
Wakefulness Test and Multiple Sleep Latency Test) are only modestly correlated with
one another, suggesting only a modest correlation between OSA severity (measured by
AHI) and sleepiness (Gottlieb, et al., 1999). However, those that perceive a benefit from
CPAP therapy are more likely to be adherent (Poulet, et al., 2009; Sparrow, et al., 2010;
Wolkove, et al., 2008). In a prospective, descriptive study of 122 participants, those with
higher depression scores, more emotional complaints, more feelings of social isolation,
and less energy were more likely to be adherent (Poulet, et al., 2009). It is well known
that sleepiness is multi-factorial, but this may contribute to adherence if no improvement in symptomology is detected with CPAP use (Lewis, et al., 2006).

**Self-efficacy.** CPAP self-efficacy in terms of Bandura’s Social Cognitive Theory strongly correlated with subsequent CPAP adherence (Sawyer, Canamucio, et al., 2010). In a prospective longitudinal study including 66 participants, CPAP self-efficacy was positively influenced by education, and correlated with CPAP use at four months (Sawyer, Canamucio, et al., 2010). Another study examining educational message framing in 70 patients found that self-efficacy increased with exposure to, and experience with CPAP, and was highest in those with the most CPAP use at 30 days (Trupp, et al., 2011). The authors concur that self-efficacy is modifiable and may optimize adherence with little risk (Trupp, et al., 2011). Inherently, CPAP self-efficacy enhances one’s ability to overcome perceived barriers (Sawyer, Deatrick, et al., 2010).

**Significant other.** Many patients requiring CPAP have a significant other who may also play a role in the patient’s acceptance and adherence to CPAP. In a RCT, bed partners were invited to attend the CBT intervention, though no significant differences were detected in CPAP adherence for those with bed partners in attendance (Richards, et al., 2007). In contrast, in a classic study, partner support improved CPAP usage (Hoy, et al., 1999). Indeed, bed partners may provide an immediate source of support for the CPAP user as well as provide feedback on treatment (Weaver & Sawyer, 2010). Another interesting finding is that CPAP use may improve relationship quality (Kelly Glazer Baron, Smith, Czajkowski, Gunn, & Jones, 2009; Simon-Tuval et al., 2009). More research is needed to determine a true link between social support and improved adherence, though current research indicates that significant others provide a positive
influence (Sawyer, Deatrick, et al., 2010; Sawyer, et al., 2011; Simon-Tuval, et al., 2009; I. Smith, et al., 2009). However, it should also be noted that a significant other may not only promote but also impede CPAP adherence (Broström et al., 2010).

Barriers to CPAP Adherence

Reasons for lack of acceptance and subsequently adherence include: (a) dislike of CPAP trial, (b) no perceived illness by the patient, (c) cost, (d) claustrophobia, (e) and noise and discomfort of the apparatus (Wolkove, et al., 2008). Nonadherent patients often have negative perceptions of early treatment and perceive the drawbacks of CPAP therapy to outweigh the benefits (Sawyer, Deatrick, et al., 2010). Barriers to CPAP adherence include, but are not limited to: (a) discomfort with the CPAP apparatus, (b) significant others, (c) low socioeconomic status, (d) younger age, (e) status of OSA as a chronic illness, (f) psychological factors and (g) residual sleepiness.

Discomfort with the CPAP apparatus. Many technological advances have attempted to address side effects related to CPAP (Weaver & Sawyer, 2010). Though, discomfort continues to be a problem as evidenced by complaints of nasal stuffiness, dry eyes, feelings of claustrophobia, and problems with exhaling (Broström, et al., 2010)

Significant other. Significant others have already been identified as facilitators of adherence, however they may also serve as barriers to CPAP adherence. Although Hoy, et al. (1999), affirms that increased partner involvement improved CPAP usage, patients who were referred by themselves had higher CPAP usage than those that were partner-referred. Indeed, a small, descriptive, explorative study identified spouses as barriers if they provided insufficient emotional and practical support during initiation of
CPAP and when side-effects were encountered (A. Brostrom, et al., 2010). Another small study that explored relationship quality and CPAP adherence found that marital conflict was inversely related to CPAP adherence (Kelly Glazer Baron, et al., 2009). In addition, spouse’s anger and criticism directly influences CPAP use, whereas a lower concern for the OSA sufferer may indirectly influence CPAP adherence (Kelly Glazer Baron, et al., 2009). Conversely, a descriptive study reported that nonadherent patients were often single, divorced, or widowed and rarely discussed their social network as important to their therapy (Sawyer, Deatrick, et al., 2010).

**Low socioeconomic status.** Recently, CPAP adherence has been explored in terms of socioeconomic status (Platt et al., 2009; Roecklein, et al., 2010; Simon-Tuval, et al., 2009). In a large, retrospective cohort study evaluating effect of neighborhood of residence in veterans, lower neighborhood-level socioeconomic status was predictive of lower CPAP adherence, independent of other individual characteristics including race (Platt, et al., 2009). In an Israeli cross-sectional, prospective study, low-income independently predicted decreased acceptance of CPAP (Simon-Tuval, et al., 2009). Roecklein, et al. (2010), also reported a large economic barrier in CPAP acceptance among a small naturalistic study utilizing personal feedback to promote adherence in a sample of mainly low-income African-American women. It shall be noted that although two of the aforementioned studies have a large African American sample, race was not significantly associated with CPAP adherence and adherence was similar in African Americans and Caucasians (Platt, et al., 2009; Roecklein, et al., 2010).

**Age.** Although the studies incorporating age into their analysis differ greatly in design and objective, it appears that younger OSA patients may be less adherent
(Budhiraja, et al., 2007; Kasai et al., 2008; Poulet, et al., 2009; Simon-Tuval, et al., 2009). In a study exploring socioeconomic impact on CPAP acceptance and adherence, younger patients were less likely to accept treatment, perhaps due to lower incidence of cardiovascular disease and hypertension, and a perceived lack of symptoms (Simon-Tuval, et al., 2009). In another study exploring psychological variables and the impact on adherence, younger patients used CPAP less than older patients (Poulet, et al., 2009). Younger patients were also more likely to experience mask-related problems and have shorter sleeping times possibly contributing to decreased compliance with CPAP (Kasai, et al., 2008).

**OSA as a chronic illness.** OSA has only recently been recognized as a chronic illness, most effectively treated with CPAP worn every night (Stepnowsky, Palau, Gifford, & Ancoli-Israel, 2007). Chronic illnesses are characterized by insidious onset, indefinite or perpetual duration, multifactorial causation, and a focus towards management of symptoms rather than a cure (Stepnowsky, Palau, Gifford, et al., 2007). Poor adherence to health related interventions, such as CPAP, is common in patients with chronic illnesses (Budhiraja, et al., 2007; Hoy, et al., 1999). Education and targeting of psychosocial and cognitive traits may be the cornerstone in treating OSA with CPAP if other chronic conditions are evidence (Trupp, et al., 2011).

**Psychological factors.** There are many intervention studies that seek to promote adherence to CPAP. However, there are several descriptive studies which attempt to elicit rationale for discontinuation or lack of CPAP adherence. A recent mixed method, descriptive study of 30 interviews determined that the social cognitive construct of knowledge was a barrier in those who did not adhere (Sawyer, Deatrick, et al., 2010).
These participants’ knowledge and perception of OSA were inaccurate and they lacked a goal-oriented plan for continuing CPAP (Sawyer, Deatrick, et al., 2010). Another prospective, descriptive study consisting of 122 participants determined that emotional reactions and social isolation as measured by the Nottingham Health Profile, predicted nonadherence (Poulet, et al., 2009). Negative attitudes toward therapy were identified before and during CPAP therapy in patients that were ultimately nonadherent in a descriptive exploratory study (Broström, et al., 2010).

**Residual sleepiness.** Another potential barrier to the use of CPAP is residual sleepiness experienced by faithful CPAP users (Mulgrew et al., 2010). Those that experience residual sleepiness in spite of CPAP treatment, may exhibit abnormalities in the emotional reaction domain of the Nottingham Health Profile, which assesses health-related symptomology (Poulet, et al., 2009). Residual sleepiness experienced by 22.3% of patients in a Japanese study, decreased the quality of life and may have been attributed to shorter sleeping time (Kasai, et al., 2008). Indeed other factors should be considered when addressing residual sleepiness (Santamaria, Iranzo, Montserrat, & de Pablo, 2007). Depression (found in 40% of OSA patients), insomnia, and insufficient sleep are some other potential causes of sleepiness that may impede symptom improvement with CPAP treatment if left unaddressed (Nguyen, Chaskalovic, Rakotonanahary, & Fleury, 2010; Santamaria, et al., 2007). It is apparent that sleepiness is the result of more than sleep apnea alone (Gottlieb, et al., 1999).

Residual sleepiness may affect CPAP efficacy. Mulgrew, et al. (2010), reports that outcomes, such as sleepiness, quality of life, and CPAP compliance were poorer for those that experienced residual sleepiness. A recent RCT evaluating outcomes
related to CPAP, found that even patients maximally compliant with treatment failed to
improve in several neurocognitive areas after three months of treatment (Antic et al.,
2011). Frighteningly, this may contribute to permanent and irreversible hypoxic brain
damage which may affect neuro-cognition (Antic, et al., 2011).

**Instrumentation and outcomes**

The primary outcome of many of the studies was CPAP usage, but measures of
excessive daytime sleepiness, quality of life, and self-efficacy were important in
determining reasons for continued usage (Ballard, Gay, & Strollo, 2007; Richards, et al.,
2007; C. E. Smith, et al., 2009; Sparrow, et al., 2010). The Epworth Sleepiness Scale to
measure excessive daytime sleepiness (Kelly Glazer Baron, et al., 2009; Damjanovic, et
al., 2009; Fuchs, et al., 2010; Gottlieb, et al., 1999; Kohler, et al., 2010; Richards, et al.,
2007; Roecklein, et al., 2010; Sawyer, Canamucio, et al., 2010; I. Smith, et al., 2009;
Stepnowsky, Palau, Marler, et al., 2007; Trupp, et al., 2011; Weaver, et al., 2007);
Functional Outcomes of Sleep Questionnaire (Ballard, et al., 2007; Kelly Glazer Baron,
et al., 2009; Sparrow, et al., 2010; Weaver, et al., 2007) to determine quality of life;
Nottingham Health Profile (Poulet, et al., 2009) to determine health related
symptomology; Center for Epidemiological Studies Depression Scale to evaluate
depression (Kelly Glazer Baron, et al., 2009; Hoy, et al., 1999; C. E. Smith, et al., 2009;
Sparrow, et al., 2010; Trupp, et al., 2011); Psychomotor Vigilance Task to evaluate
reaction time (Sparrow, et al., 2010); and the Self-Efficacy Measure for Sleep Apnea to
evaluate cognitive factors which may influence CPAP use (Kelly Glazer Baron, et al.,
2009; Sawyer, et al., 2011; Sparrow, et al., 2010; Trupp, et al., 2011); were tools used
throughout the literature. Taylor et al. (2006) modified the Functional Outcomes of Sleep
Questionnaire to make it applicable to military personnel. The primary outcome of CPAP use was objectively measured with a microchip in the CPAP machine, (Aloia, et al., 2007; Kelly Glazer Baron, et al., 2009; Budhiraja, et al., 2007; Meurice, et al., 2007; Platt, et al., 2009; Roecklein, et al., 2010; C. E. Smith, et al., 2009; Sparrow, et al., 2010; Weaver, et al., 2007), and subjectively measured by patient report, which was less reliable (Sawyer, Canamucio, et al., 2010; Wolkove, et al., 2008).

Strengths of Studies in Review

The majority of studies conducted on CPAP adherence recognized 4 hours or more as the cutoff for acceptable CPAP adherence, some even before CMS (2008) used this as the threshold for coverage (Aloia, et al., 2010; Ballard, et al., 2007; A. Brostrom, et al., 2010; Budhiraja, et al., 2007; Olsen, et al., 2008; Platt, et al., 2009; Poulet, et al., 2009; Richards, et al., 2007; Simon-Tuval, et al., 2009; C. E. Smith, et al., 2009; Sparrow, et al., 2010; Trupp, et al., 2011). This four hour threshold creates a homogeneity that allows for more appropriate comparison among different studies on the same topic.

Another strength among the CPAP adherence literature was the heterogeneity of study design. The variety of study designs allows for an in-depth look at the issue. Numerous study designs were utilized in the literature: quasi-experimental (Weaver, et al., 2007); RCT with four treatment arms (Damjanovic, et al., 2009; Meurice, et al., 2007); RCT with three treatment arms (Aloia, et al., 2007; Stepnowsky, Palau, Gifford, et al., 2007); RCT (Antic, et al., 2011; Ballard, et al., 2007; Hoy, et al., 1999; Lewis, et al., 2006; Mulgrew, et al., 2010; Richards, et al., 2007; Roekelein, et al., 2010; C. E. Smith, et al., 2009; Sparrow, et al., 2010; Stepnowsky, Palau, Marler, et al., 2007;
Taylor, et al., 2006; Trupp, et al., 2011); descriptive study (A. Brostrom, et al., 2010; Anders Brostrom et al., 2009; Poulet, et al., 2009); retrospective cohort study (Aloia, et al., 2010; Budhiraja, et al., 2007; Kohler, et al., 2010; Platt, et al., 2009; Wolkove, et al., 2008); prospective cohort study (K. G. Baron et al., 2010; Gottlieb, et al., 1999; Kasai, et al., 2008; Nguyen, et al., 2010; Sawyer, Canamucio, et al., 2010); cross-sectional prospective study (Fuchs, et al., 2010; Simon-Tuval, et al., 2009); meta-analysis (Patel, et al., 2003; I. Smith, et al., 2009); and a systematic review (Olsen, et al., 2008).

In addition to the differences in study designs, there are a number of countries which have conducted studies on CPAP adherence outside the United States. This allows for a broader view of the issue and potentially a comprehensive solution. Studies have been conducted in Japan (Kasai, et al., 2008), Australia (Antic, et al., 2011; Richards, et al., 2007), Germany (Damjanovic, et al., 2009; Fuchs, et al., 2010); France (Meurice, et al., 2007; Nguyen, et al., 2010; Poulet, et al., 2009), Switzerland (Kohler, et al., 2010), Sweden (Broström, et al., 2010; Anders Brostrom, et al., 2009), Canada (Wolkove, et al., 2008), Israel (Simon-Tuval, et al., 2009), and the United Kingdom (Hoy, et al., 1999; Lewis, et al., 2006). One French study reported significantly higher compliance (80%) in their population, compared to the United States (Meurice, et al., 2007). However, the threshold for treatment was severe sleep apnea, whereas other studies allowed moderate and even mild sleep apnea (Meurice, et al., 2007).

**Weaknesses of Studies in Review**

One weakness in several studies was the subjective reporting of CPAP use (Fuchs, et al., 2010; Kasai, et al., 2008; Wolkove, et al., 2008). It is recognized that self-reporting of CPAP use may overestimate use by approximately one hour (Weaver &
Sawyer, 2010). This is significant given the dose-response effect of therapy (Weaver, et al., 2007). In addition to self-reporting CPAP use, Fuchs et al. (2010), allowed subjective reporting of educational lecture, which may have skewed results further.

Another weakness in the literature may be inherent lack of usual care. Many of the studies may overestimate the benefits of usual care because standard support in these studies was greater than typically given in many sleep centers (Damjanovic, et al., 2009; Hoy, et al., 1999; Meurice, et al., 2007). Two European studies admit that their standard support is more intensive and may have contributed to the increased compliance in these trials (Damjanovic, et al., 2009; Meurice, et al., 2007). Hoy et al. (1999) included an educational video, time spent with the CPAP mask on before polysomnographic titration, and frequent follow-up phone calls and clinic visits in their usual care.

Underpowered studies were found throughout the CPAP adherence literature. In a study evaluating the effect of tele-monitoring on CPAP adherence, statistically significant conclusions could not be drawn due to the small sample size (Stepnowsky, Palau, Marler, et al., 2007). In this study 45 patients signed consent forms, but shortly after the study began five dropped out and 42 patients were necessary to reach a power of 0.70 (Stepnowsky, Palau, Marler, et al., 2007). Another study evaluating relationship quality and adherence, adherence data was available for only 23 limiting the ability to draw conclusions (Kelly Glazer Baron, et al., 2009). Roecklein et al. (2010) discussed personalized feedback and CPAP adherence in 20 patients (with two lost to follow-up) whereas 40 were needed for adequate analysis.
Gaps in the Literature

One gap noted in the CPAP adherence literature is the use of only CPAP naïve patients for intervention studies. Promoting CPAP adherence in those previously non-adherent is sparsely described in the literature, but adherence may be improved with a more comfortable mode of therapy when standard interventions (ie. education and counseling) fail (Ballard, et al., 2007). Fuchs et al. (2010) found that participants previously diagnosed and treated for OSA who attended an educational lecture were more CPAP adherent, though subjective reporting, non-randomization, and motivation may have influenced these results.

There was little diversity reported in the literature, as many of the participants were Caucasian, middle-aged, male, and many were veterans (Platt, et al., 2009; Sawyer, Canamucio, et al., 2010; Sparrow, et al., 2010; Stepnowsky, Palau, Marler, et al., 2007; Taylor, et al., 2006). In a classic RCT to evaluate an intervention to improve CPAP usage, 78 participants of 80 were male and mean age was 51 years (Hoy, et al., 1999). One underpowered, pilot intervention examined the effects of personal feedback in a sample of mainly low-income, African American women, but the sample was too small to accurately portray an effect (Roecklein, et al., 2010).

In every study, there were patients lost to follow-up. However, CPAP use in these patients is important because they represent a portion of the total sample (I. Smith, et al., 2009). Thus, if these patients are not using their CPAP machines, the figures obtained by researchers may be falsely elevated for CPAP adherence. Therefore, future studies examining those patients lost to follow-up are necessary to form a complete picture of the problem of CPAP adherence.
Summary

The literature on CPAP adherence was reviewed in depth and broken down in the context of facilitators of and barriers to adherence. It is clear that the problem of CPAP adherence is multifaceted and each individual has their own barriers and facilitators to reckon with (Lewis, et al., 2006). However, numerous studies exist to address this issue in various populations, with limited success. Programs designed to improve CPAP adherence must be practical, cost-effective, and individualized enough to address the unique situation of each patient. Programs should be implemented early, perhaps even before treatment initialization, to potentially augment cognitive constructs related to CPAP and enhance adherence. Barriers should be addressed promptly and frequently by the provider on an individual basis.

Conclusion

Without treatment, OSA remains detrimental to the quality of life of the individual suffering from the condition and to society as a whole. Although treatment with CPAP has been proven efficacious, adherence is generally poor as with other chronic conditions. Therapies that address the cognition of the OSA patient have shown the most success. However, future studies may focus on the cognition of the OSA patient while recognizing the chronic nature of OSA. Future research may also explore long term treatment efficacy in improving quality of life and adherence patterns. More research is also needed to ascertain the true benefit of treatment outcomes of OSA treated with CPAP in monetary terms. In addition, sample sizes should be maximized to provide adequate analysis from which to draw conclusions. Patients who reject CPAP
immediately and those who are lost to follow-up are not well defined in the CPAP literature and future studies may focus on outcomes of these patients. Many studies have addressed CPAP adherence, though it is still a problem. Perhaps the answer to optimal adherence to CPAP lies in the suggested directions for future research.
References


