Patient Adherence with Positive Airway Pressure Devices Used in the Treatment of Obstructive Sleep Apnea: Contributing Factors at Sleep Centers

by

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Abstract

Introduction Positive airway pressure (PAP) adherence in the patient with obstructive sleep apnea (OSA) has been a problem for many years. This research aims to explore PAP adherence and variables affecting adherence. Positive airway pressure is the primary treatment for OSA and is effective; however, many patients that are diagnosed with this disease do not adhere to the PAP therapy. **Methods** A retrospective data review of existing patient records was utilized. This method uses the electronic medical records for retrieval of pertinent medical data for available OSA cohort data ascertaining a relationship between the adherence of PAP therapy, the disease specific Charlson Comorbidity Index (CCI), and the credential level of discharger. Demographic variables of age, gender, ethnicity, and healthcare coverage were compared to PAP compliance. Pertinent data were then compiled with analysis performed by Intellectus statistical analysis software. Descriptive and inferential statistics were used to address all research questions. Binary logistic regression analysis was used to evaluate existing relationships. **Results** Analyzed data revealed past PAP failure showed a significant effect on the odds of observing current PAP compliance. The overall model revealed that demographic variables, CCI, and credential level of medical provider were non-significant for PAP adherence. **Conclusion** The significance of PAP adherence training is epitomized by the sheer economic and societal impact that untreated OSA retains on the population. Patients with known OSA require effective treatment, and as PAP therapy is still considered the first-line gold standard modality for doing so, it is the responsibility of the sleep medicine community to ensure PAP adherence rates improve.

Keywords: adherence, compliance, obstructive sleep apnea (OSA), positive airway pressure (PAP), sleep centers, sleep medicine

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Chapter 1

Introduction

Sleep is critical to health and overall well-being with sleep loss being a global problem. Two of the objectives of *Healthy People 2030* are to increase the number of adults who get sufficient sleep and educate the public about the positive effects of good sleep hygiene and the treatment of sleep disorders (Office of Disease Prevention of Health Promotion, n.d.). Obstructive sleep apnea (OSA) is one of the most diagnosed and common forms of sleep-related disorders (Shapiro, 2021). This is exemplified by an increasing prevalence of 15% of males and 5% of females across the U.S. population who retain the sleep disorder (Bohorquez et al., 2020). Moreover, an estimated 29.4 million American adults and 1.6 million children are afflicted by this chronic sleeping condition (Watson, 2016). OSA is universally defined as recurrent episodes of partial or complete upper airway collapse during sleep that induces intermittent apneas and repeated episodes of nocturnal desaturation (Edwards et al., 2020; Spriggs, 2015). In turn, the pathophysiological processes involved with untreated OSA will inevitably result in fragmented sleep, poor sleep quality, and a profound reduction in one's overall quality of life (Boon et al., 2018; Ratneswaran et al., 2021; Sturm et al., 2019).

With positive airway pressure (PAP) therapy universally considered a first-line therapeutic option for reducing the subjective symptoms and objective comorbidities of moderate-to-severe OSA, it is imperative that patients become adherent to wearing their PAP devices nightly. Optimal PAP adherence is defined by the Centers for Medicare and Medicaid Services (CMS) as a mean of ≥ 4 hours of use for ≥ 70% of nights. It is essential to improving patient outcomes and should be a primary focus of all sleep

education programs for this reason alone (Kakkar & Berry, 2007). However, the inability to properly acclimate to PAP therapy has limited its use as a nightly treatment regimen for OSA patients. OSA results in poor sleep hygiene, requiring PAP therapy, yet 30% of those who are diagnosed with OSA and are recommended to be treated, are not adherent (Knauert et al., 2015). Sleep disorders have become an increasing concern within the medical community. This increase in attention is owed to long-term health complications that may arise from untreated sleep disorders. In addition to an increase in general health risks, sleep disorders that remain untreated retain a substantial capacity to induce negative societal consequences. Workplace incidents and motor vehicle accidents are examples of the societal burdens produced by symptomatic disorders of sleep that are not optimally treated (Ratneswaran et al., 2021; Watson, 2016; Woodson et al., 2018). For these reasons, it is imperative that sleep disorders among the U.S. population are promptly diagnosed and effectively treated.

The subjective manifestations of untreated OSA typically culminate in the chief complaint of excessive daytime sleepiness (EDS) with a lack of concentration or variable memory loss throughout the day. If ignored, untreated OSA has been associated with clinical depression, although further research on this matter is required to verify causation (Carlin, 2019; Edwards et al., 2020; Spriggs, 2015). Cardiovascular comorbidities, such as hypertension, cardiac disease, arrhythmia, and stroke, have a well-documented association with cases of moderate-to-severe OSA that remains untreated (Boon et al., 2018; Carlin, 2019; Heiser et al., 2019; Spriggs, 2015). Consequently, both the subjective and objective complications associated with untreated OSA are an established, tangible threat to the representative U.S. populace affected by the disorder.

Untreated OSA associated with a multitude of comorbid conditions, but it also has a lasting fiscal impact on the U.S. economy and healthcare system if left untreated (Watson, 2016). The overall estimated economic burden of undiagnosed, and therefore untreated, OSA was approximately $150 billion USD in 2015. This included $6.5 billion USD attributed to workplace incidents, $26.2 billion USD in relation to motor vehicle accidents, $86.9 billion USD towards lost productivity, and $30 billion USD via comorbid conditions (Watson, 2016). Nevertheless, it has also been estimated that by treating every adult in the United States who currently has OSA, a projected annual savings of $100 billion USD would occur (Watson, 2016). OSA truly poses a hidden threat to society in a manner that extends beyond the diagnostic laboratory setting. Poor treatment adherence is a problem. The CMS adherence guidelines dictate that the cost of PAP is covered only for the first three months after the initial diagnosis of OSA. Coverage beyond that period is contingent on adequate adherence to, and adequacy of, treatment with PAP. Adherence is defined as using PAP for four or more hours per night for at least 70% of nights during a consecutive 30-day period anytime during the first three months of initial usage. CMS does not provide coverage beyond 12 weeks if patients do not meet adherence and self-reported clinical improvement guidelines (Center for Medicare and Medicaid Services, n.d.). According to the CMS inventory tool, the adherence threshold was arbitrarily defined (Center for Medicare and Medicaid Services, n.d.).

The significance of poor adherence to treatment of chronic conditions is well known (Sabaté & Geest, 2004). When PAP adherence is the prescribed regimen, the adherence rate shrinks dramatically. Weaver (2019) explored the minimal amount of CPAP needed

per night that will have a positive effect. The results indicated that while subjective sleepiness was alleviated after four hours of CPAP use per night for three months, objective sleepiness measures indicated that a minimum of six hours of CPAP per night was needed. The patients' functional status normalized after 7.5 hours of nightly CPAP use for three months. More CPAP is likely to yield better results, but the level of CPAP use that produces the best outcome differs based on disease severity, symptoms, and has not yet been clearly defined (Weaver, 2019).

Unlike treatments for other chronic conditions, any use of CPAP provides benefits and is better than no use at all. The improvement in clinical outcomes is positively related to the nightly hours of CPAP therapy, but some patients may experience similar benefits with fewer hours of CPAP therapy.

Factors That May Challenge PAP Adherence

Many factors affect adherence in general. Adherence can be defined as "the extent to which patients follow the instructions they are given for prescribed treatments" (Shapiro, 2021, pg 21), but this definition does not reflect the fluctuation in adherence behavior. The ability and/or willingness of the patients to follow the directives of a treatment plan are often impaired by a variety of elements that encompass distinct aspects of the problem. Included are socioeconomic factors, such as the: disease characteristics, treatment itself, healthcare education given, and patient-related factors (Boon et al., 2018). All these factors influence adherence, often concurrently, and make this challenging therapy extraordinarily complex

While the reasons for PAP therapy noncompliance are multifactorial and dependent upon the individual patient, they are nonetheless clinically meaningful. To

diminish the societal and economic impact that untreated OSA continues to retain, professionals must strive for an OSA population that demonstrates optimal compliance in their treatment regimens.

Adherence to CPAP is complex and dependent on many circumstances, as well as influenced by socioeconomic factors and education (Shapiro, 2021). A considerable impediment to optimized adherence is the social stigma that has continued to surround PAP therapy for its entire existence as an application to treat sleep apnea (Shapiro, 2021). Patients have long reported the devices as overly cumbersome and in some instances, embarrassing to wear (Shapiro, 2021). In these cases, it is useful for sleep medicine practitioners to be proficient in motivating patients towards complying with PAP therapy. They can do this by explaining why patients would benefit from wearing the device and encouraging an increasingly cheerful outlook towards the therapy. Shapiro notes that an attitude that manifests an optimistic outlook on PAP therapy has been reported to facilitate an increase in adherence. As the sleep medicine practitioner is the patient's initial contact upon first attempting PAP therapy, it is the practitioner's responsibility to support this cheerful outlook and encourage PAP compliance.

Training Level of the Healthcare Educator

It was discovered in previous research that OSA patients reported a lack of education and support from their healthcare providers, whether the providers were sleep specialists or other healthcare providers (Adusumilli et al., 2017). Sleep medicine and Registered Polysomnography Technologists (RPSGTs) are still in their infancy in the world of medicine. Over the last 15 years, sleep medicine has experienced much growth (Schulz & Salzarulo, 2016). From 2000 to 2010, the number of American Academy of

Sleep Medicine (AASM) accredited sleep centers quadruped from approximately five hundred to more than two thousand (Kirsch, 2013). A cause for this increase is awareness of sleep health and the risks associated between disrupted sleep, obesity, diabetes, and cardiovascular disease.

The Board of Registered Sleep Technologists (BRPT) professionally credentials registered sleep technologists. Since the first credentialing exam administration in 1979, the BRPT has credentialed over 22,000 RPSGTs in the United States, Canada, and thirty-two countries overseas (Board of Registered Polysomnographic Technologists, n.d.). Currently, the highest degree available in sleep technology is an associate degree; however, individuals can choose a certificate instead of an associate degree or advance to a bachelor's degree. With international recognition, the RPSGT is the "gold standard" of credentialing in sleep medicine because it represents the highest certification in the field for healthcare professionals who clinically assess patients with sleep disorders. It gets complicated and convoluted due to other credentials established by different founding bodies fighting for the "gold standard" title. A few of the other credentials recognized in the field of sleep are the Registered Respiratory Therapist (RRT), the Respiratory Therapist with the Sleep Specialty credential (RRT-SDS), Registered Sleep Technologist (RST), and the Certified Clinical Sleep Health Educator (CCSH). Each one of these credentials follows a different educational pathway, with different educational requirements.

Prior PAP Failure

Assessing influence of socioeconomic factors and healthcare non-adherence on specific populations, like people with OSA, is an essential step in the optimization of

PAP delivery. The concept of healthcare non-adherence can correspond to societal or personal conducts and/or beliefs leading individuals to become non-adherent. A large part of research on the non-adherent healthcare phenomenon has focused on underprivileged populations who forgo healthcare primarily for financial reasons. However, multiple reasons for PAP nonadherence are also reported by individuals without financial constraints, such as: lack of time owing to the burden of professional or personal life, lassitude or negligence, and diminished knowledge of the benefits of the therapy being prescribed (Shapiro, 2021). In addition, some studies on the concept of non-adherence show that not all people are exposed in the same way to this phenomenon.

Charlson Comorbidity Index

The Charlson Comorbidity Index (CCI) is a method of categorizing patients' comorbidities, and there are about nineteen conditions in the index. The comorbidity is ranked from one to six, and the sum results in a score for patients. A higher score in the index increases the odds of mortality. Sleep disorders, like obstructive sleep apnea, are also a contributing factor in the index. The presence of comorbidities in patients adds health risks, which increases their mortality rate in this index.

Obstructive Sleep Apnea is associated with diseases such as stroke, heart arrhythmias and cardiovascular diseases (Chiang et al., 2017). A direct relationship between patients with OSA and the CCI could be identified if monitored in sleep labs. This association could further indicate that patients with comorbidities and OSA may have a higher mortality risk than patients without the underlying comorbidities. See Appendix A for more information on the CCI.

Financial Issues

OSA correlates with an escalation of healthcare costs (Olsen et al., 2008). The medical consequences of untreated OSA are many, and each one contributes to the economic burden on employers and society. Patients with undiagnosed OSA have $1,950 to $3,899 greater healthcare costs than those without OSA. Patients with OSA treated with CPAP cost $2700-$5200 less that those who have an OSA diagnosis without treatment (Knauert et al., 2015). In the United States alone, 42.5 million people over the age of thirty are OSA positive, which explains the impact of OSA on healthcare costs (Knauert et al., 2015).

Demographic Variables

Patient demographics and disease severity indices drive CPAP adherence, but research has revealed that these factors only explain a small amount of variance in adherence. Age and gender do not appear to influence CPAP adherence, or there is only a weak relationship, which is often not clinically relevant (Boon et al., 2018). The general lack of data examining these variables promotes further study of these relationships. A review of archived data investigating return-for-titration rates showed no difference in return rates between genders. Interestingly, women allowed more time to elapse between the diagnostic and the titration studies than men.

Race and Ethnicity

Though there is a paucity of research on the influence of race and ethnicity on adherence, the findings indicate that minority populations are often less successful in adhering to the prescribed CPAP regimen (Wallace & Wohlgemuth, 2014). Several studies reported a lower CPAP adherence among African American CPAP users compared to White or Hispanic CPAP users (Weaver, 2019). Most recently, Wallace &

Wohlgemuth (2014), confirmed the equivalent adherence in U.S. Hispanics and Whites, with poorer adherence in African Americans. Because little is known about the influence of race and ethnicity on CPAP use and adherence, therefore, Weaver,(2019) called for an exploration of ethnicity and race characteristics that may influence CPAP use. A review of participants' ethnicity in sleep disorder trials suggests that the number of minority participants was low. This limited participation by minorities could affect the true evaluation of adherence to, and effectiveness of a treatment (Weaver, 2019). No research was found that investigated a correlation between ethnicity or socioeconomic status and titration completion and PAP adherence, though financial constraints could affect the timely completion of a CPAP titration study.

Socioeconomic status is another aspect of the CPAP-adherence problem, especially when considering the initiation of the treatment. Even when subsidized, the CPAP treatment is expensive. Adusimilli (2017) found that only 32% of those who had completed a titration study purchased the CPAP devices.

Statement of the Research Problem

Positive airway pressure adherence in the OSA patient has been a problem for many years. This research aims to explore PAP adherence and variables affecting it in today's sleep centers. OSA is associated with many adverse health outcomes, including an increased rate of motor vehicle crashes, hypertension, stroke, daytime sleepiness, reduced quality of life, and cardiovascular disease (Boon et al., 2018; Carlin, 2019; Heiser et al., 2019; Spriggs, 2015). PAP is the primary treatment for OSA and is effective; however, many patients that are diagnosed with this disease do not adhere to the PAP therapy. Various predictors and variables, including bed partners, age, gender,

race, socio-demographic characteristics, and disease severity, may affect PAP adherence. Adherence to medical treatments is particularly important for today's healthcare workers to follow and be aware of with their patient population. Today's higher education programs in medicine, physical therapy, respiratory therapy, nursing, and many others must know the importance of including medical adherence in their curricula. According to (Weaver, 2019) it is estimated that 29 to 83 percent of patients are non-compliant or non-adherent, when noncompliance and/or nonadherence is defined as a mean of ≥ 4 hours of PAP usage per night. According to Zajacova and Lawrence (2018), to effectively inform future educational and health improvement outcomes, the need to capture education in action, as it generates and constrains opportunity during the early lifespans of today's diseases, exists to improve patient outcomes.

Purpose and Rationale of the Study

The significance of instructing PAP adherence training is epitomized by the sheer economic and societal impact that untreated OSA retains on the population. Patients with known OSA require effective treatment, and as PAP therapy is still considered the gold standard modality for doing so, it is the responsibility of the sleep medicine community to ensure PAP adherence rates improve. To fulfill this responsibility, PAP therapy ameliorates respiratory disturbances which can lead to improved daytime sleepiness, quality of life, blood pressure, and cognition (Boon et al., 2018; Carlin, 2019; Heiser et al., 2019; Spriggs, 2015). However, despite its high efficacy, PAP adherence is often sub-optimal.

Research Questions

1. Do variables, such as age, gender, ethnicity, or type of healthcare coverage have

an impact on PAP adherence?

2. Does the Charlson Comorbidity Index predict patient PAP adherence?
3. Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?
4. Does prior PAP failure predict current PAP adherence?

Research Design

To investigate subjects' data related to the inclusion criteria outlined in this study, this research study utilized a retrospective chart review (RCR) through the electronic medical record (EMR) database. Data collection and subsequent analyses were accumulated by direct retrieval from the subjects' EMR database and the electronic health record (EHR), per establishment guidelines.

Limitations of the RCR Study

Limitations of any study conducted by a retrospective method include, but are not limited to, selection bias on the part of the investigator, unintentional mishandling of subject data while documenting in the EMR, erroneous or invalid entering of data into the EMR, and data entered for the wrong patient EMR. This could be a result of individuals improperly managing and entering the data or by multiple individuals managing the data resulting in transcription errors that lead to erroneous results and outcomes (Vassar & Holzmann, 2013). This was addressed in the study through all retrieved data being randomly sampled for control of bias. To review a distributed sample of pertinent participants, all data was complete, and multiple reviews were performed to control clerical errors, including proper handling and transcription of data. Although, because it was a preexisting data base previously compiled, some limitations were beyond control

of this study.

Definition of Terms

Adherence: the degree to which the person's behavior corresponds with the agreed recommendations from a health care provider (Cramer, 2009)

American Academy of Sleep Medicine (AASM): Established in 1975 as the Association of Sleep Disorders Centers, the AASM is the only professional society dedicated exclusively to the medical subspecialty of sleep medicine (American Board of Sleep Medicine, n.d.)

American Association of Sleep Technologist (AAST): The AAST is the premier allied health membership association for professionals dedicated to improving the quality of sleep and wakefulness in all people. AAST is committed to promoting and advancing the sleep technologist profession while meeting the professional and educational needs of more than 2,800 members (American Association of Sleep Technologists, n.d.)

Board of Registered Polysomnography (BRPT): The BRPT is an independent, nonprofit certification board that cultivates the highest professional and ethical standards for sleep health professionals by providing the leading internationally recognized credential in sleep technology – the Registered Polysomnographic Technologist (RPSGT) credential (Board of Registered Polysomnographic Technologists, n.d.)

Certification in Clinical Sleep Health (CCSH): an advanced-level examination for healthcare providers and educators who work directly with sleep medicine patients, families, and practitioners to coordinate and manage patient care, improve outcomes,

educate patients and the community, and advocate for the importance of good sleep (Board of Registered Polysomnographic Technologists, n.d.)

Compliance: Healthcare compliance is the process of following rules, regulations, and laws that relate to healthcare practices (Weaver, 2019)

Medical Licensure: legal permission given to professionals to practice in specific fields according to rules and regulations of an authority (Lustgarten & Elhai, 2018)

National Board for Respiratory Care (NBRC): The NBRC is a non-profit organization formed in 1960 with the purpose of awarding and maintaining credentialing for Respiratory Therapists in the United States (National Board for Respiratory Care, n.d.)

Obstructive Sleep Apnea (OSA): OSA is a disorder in which a person frequently stops breathing during his or her sleep. It results from an obstruction of the upper airway during sleep that occurs because of inadequate motor tone of the tongue and/or airway dilator muscles (Patil et al., 2007)

Positive Airway Pressure Treatment (PAP): Positive airway pressure (PAP) therapy is a generic term applied to all sleep apnea treatments that use a stream of compressed air to support the airway during sleep ("Positive Airway Pressure (PAP) Therapies", 2022)

Positive Airway Pressure (PAP) *Compliance:* In assorted studies, the terms "adherence" and "compliance" are often used interchangeably, and the definition of these terms is regarded as the average number of hours of nightly use. Additionally, according to the Centers for Medicare and Medical Services, adequate adherence or

compliance of CPAP is defined as using a CPAP device for ≥ 4 hours daily and ≥ 70% of nights over the course of 30 days (Mehrtash et al., 2019)

Polysomnography: derived from the Greek roots "poly," meaning many, "somno," meaning sleep, and "graphy" meaning to write, refers to multiple tests performed on patients while they sleep. Polysomnography is an overnight test to evaluate sleep disorders

Registered Polysomnography Technologist (RPSGT): "an internationally recognized credential representing the highest certification in the field for the health care professionals who clinically assess patients with sleep disorders" (National Board for Respiratory Care, n.d.)

Registered Sleep Technologist (RST): "The ABSM Sleep Technologist Registry Examination was developed by a Sleep Technologist Examination Committee comprised of senior members of the sleep technology profession and the sleep medicine field" (American Board of Sleep Medicine, n.d.)

Sleep Disorder Specialist (SDS): The Respiratory Therapist Sleep Disorder Specialty (RRT-SDS) examination emerged objectively measuring the knowledge and skills of respiratory therapists who perform sleep disorder testing and therapeutic intervention Sleep Disorders Specialty (SDS) testing. The RRT-SDS signifies experience and education in the field of sleep medicine (National Board for Respiratory Care, 2021)

Summary

Chapter One was an introduction to the historical aspect of this dissertation topic, *Patient Adherence with Positive Airway Pressure Devices Used in the Treatment of Obstructive Sleep Apnea: Contributing Factors at Sleep Centers.* This introduction

included a statement of the problem, a purpose and rationale for the study, a gap in available pertinent research, a hypothesis of the study, the research design, limitations of the proposed study method, and a list of definitions and terms commonly referred to throughout this research study. Chapter Two disseminates the immense available literature on the historical aspects of OSA and PAP adherence and the burden on healthcare expenditures due to lifestyles, health behaviors, and lack of health care adherence. This will lead into Chapters Three, Four, and Five presenting the methods section, data analysis, and discussion of the results.

Chapter 2

Review of Literature

The science of sleep is one such entity that has both puzzled and fascinated our predecessors throughout the epochs of time. From Egypt to Greece in antiquity, ancient civilizations had already associated sleep with overall well-being and attempted to interpret the tangible significance of dreams (Kirsch, 2011). Some renowned sleep disorder classifications, such as nightmares, were documented in ancient Greek, Roman, and Arabic text (Schulz & Salzarulo, 2016). Following the fall of the Western Roman Empire in the fifth century BC and the resulting Dark Ages, a resurgence of sleep-related theories emerged within medical institutions throughout the Scientific Revolution of the early modern era, occurring during the 16th and 17th centuries CE. After many theorems regarding the mechanisms of sleep throughout this period were postulated, groundbreaking evidence of the fundamentals of brain function and its interrelations with sleep were put forth in the 19th century CE (Kirsch, 2011).

The 19th century CE is often regarded as a renaissance period of sleep, as many foundational constructs of modern sleep medicine were discovered during this time through objective experimentation. In 1863, Ernst Otto Heinrich Kohlschütter was the first to examine the depth of sleep and demonstrate variations in awakening thresholds via systematically applied acoustic stimuli (Schulz & Salzarulo, 2016). A decade later in 1873, Camillo Golgi was the first to validate the existence of nerve cells, and Richard Caton revealed the existence of action potentials located within the brain in 1875 (Kirsch, 2011). Thus, it was substantiated from these findings that the nervous system invoked

some degree of electrical activity. Further hypotheses hoping to explain the mechanisms of sleep were developed from this newly acquired knowledge.

Despite these considerable advancements, the brain is the preeminent organ responsible for alertness, wakefulness, and the regulation of sleep (Spriggs, 2015). Therefore, it would not be until the advent of the electroencephalogram (EEG) that modern sleep medicine, as it has come to be recognized, was established. Technological advancements throughout the early to mid-20th century BC such as the development of the electrooculogram (EOG), culminated in the official recognition of distinct stages of REM and NREM sleep. Due to these advancements during the 1950s, Kleitman and William Dement recognized definite patterns associated with each individual stage(Kirsch, 2011; Schulz & Salzarulo, 2016). In turn, this resounding breakthrough progressed to the modern concept of sleep naturally cycling between various depths of NREM stages and REM sleep. Still today, professionals objectively measure sleep in an identical way using EEG recording.

According to Watson (2016), sleep has serious health consequences on individuals. Sleep disorders have become a recent and developing concern within the medical community (Watson, 2016). This increase in attention is owed to long-term health complications that may arise from untreated conditions regarding sleep. In addition to an increase in general health risks, sleep disorders that remain untreated retain a substantial capacity to induce negative societal consequences. Workplace incidents and motor vehicle accidents are just a couple of examples of the societal burdens produced by symptomatic disorders of sleep that are not optimally treated (Ratneswaran et al., 2021;

Woodson et al., 2018; Watson, 2016). For these reasons, it is imperative that sleep disorders among the U.S. population are promptly diagnosed and effectively treated.

OSA is one of the most diagnosed and common forms of sleep-related disorders of breathing (Shapiro, 2019). This is exemplified by an increasing prevalence of 15% of males and 5% of females across the U.S. population that retain the sleep disorder (Bohorquez et al., 2020). An estimated 29.4 million Americans adults are afflicted by this chronic sleeping condition (Watson, 2016).

OSA is universally defined within the literature as recurrent episodes of partial or complete upper airway collapse during sleep that induces intermittent apneas and repeated episodes of nocturnal desaturation (Edwards et al., 2020; Spriggs, 2015). The pathophysiological processes involved with untreated OSA will inevitably result in fragmented sleep, poor sleep quality, and a profound reduction in one's overall quality of life (Boon et al., 2018; Ratneswaran et al., 2020 Sturm et al., 2019).

Patient education is paramount to the control of sleep disorders such as OSA (Weaver, 2019). Weaver posits that patient education is key to raise awareness about sleep and the disorders associated with it, thereby informing the patients about the plausible causes and treatments of sleep disorders. The education component can help to enhance health and life quality by guiding patients through managing sleep disorders (Aardoom et al., 2020).

Sleep centers have a focus on educating patients to better understand the mechanisms of controlling sleep disorders. Patient education provides individuals and their caregivers with information that helps them to define and identify symptoms of sleep apnea, as well as ascertain the chance of having a sleep disorder. Key

characteristics including daytime sleepiness and snoring make it easy to detect a sleep disorder in people (Dudley & Patel, 2016).

Veaesy and Rosen (2019) found that more than half of people with sleep apnea are overweight with excessive BMI values and complained of excessive daytime sleepiness. The condition is also more common in men as compared to women. One out of every twenty-five middle-aged men studied suffered from a sleeping disorder (Veasey & Rosen, 2019). In women, sleep apnea is more prominent after menopause (Hall et al., 2015). Moreover, African Americans and Hispanics have a higher probability of developing sleep disorders compared to Caucasians (Kingsbury et al., 2013). There is also a high probability of developing sleep apnea if there is a family history of the condition. People with small airways are also prone to have sleep apnea (Hanson & Huecker, 2022) The airway problems may be due to medical conditions or allergies present that restrict the airway and cause turbulent airflow. Patient education is a suitable catalyst that helps raise patient adherence and function as a benchmark for the actions of healthcare workers. Education empowers patients to be aware of their probable condition and thus take control of their disease.

Impact of Untreated OSA

Untreated OSA has been associated with clinical depression in select individuals, although further research on this matter is required to verify a causal link (Carlin, 2019; Edwards et al., 2020; Spriggs, 2015). Cardiovascular comorbidities, such as hypertension, cardiac disease, cardiac arrhythmia, and stroke, have a well-documented association with cases of moderate-to-severe OSA that remains untreated (Boon et al., 2018; Carlin, 2019; Spriggs, 2015). Consequently, both the subjective and objective complications associated

with untreated OSA are an established and tangible threat to the representative U.S. populace affected by the disorder.

When patients are diagnosed with OSA, treatment options require these patients to partake in lifestyle changes to improve the outcomes of their illness. For an OSA patient, wearing a PAP can significantly improve quality of life (Costanzo et al., 2015). Achieving patient compliance is critical with this therapy. With no in-depth education provided to the patient regarding therapy benefits and consequences of not complying with treatment, a patient may choose to forego or be non-compliant with therapy (Dunietz et al., 2020).

PAP compliance therapy can be increased when in-depth education is provided by a trained professional (Costanzo et al., 2015). Both types of positive airway pressure treatments, Continuous Positive Airway Pressure (CPAP) and Bilevel Positive Airway Pressure (BiPAP), are currently the treatments of choice for patients with OSA (Dunietz et al., 2020). Although PAP has been proven to be a highly effective treatment, compliance with therapy remains difficult. Initial education with PAP therapy is essential in influencing compliance therapy adherence, underscoring the need for attention to patient comfort and early behavioral intervention (Hilmisson & Magnusdottir, 2019). Sleep is an essential function for health, just like everyone needs healthy food, exercise, and low stress to thrive and live a long, healthy life. Sleep is a non-negotiable biological necessity. The silent killer, sleep apnea, destroys this necessity. Sleep apnea is a more common health issue than society thinks, and it is often overlooked because the symptoms are so broad (Ho & Brass, 2011). Individuals may have fatigue, depression, trouble concentrating, headaches, and even sore throats due to sleep apnea. The

stereotype is that sleep apnea patients are overweight and snore. This is an erroneous stereotype. Adjustment disorder is among the most frequently diagnosed mental disorders in clinical practice, although it is rarely discussed in the sleep world (Patil et al., 2007) While mental health professionals often treat those suffering from adjustment disorders, research interest in the origin of the disorder or the effectiveness of psychotherapeutic and medical interventions have only recently begun to emerge (Bachem & Casey, 2018).

For an OSA patient, wearing a PAP device, whether CPAP or BiPAP, can significantly improve quality of life but can be problematic in the general patient population, and achieving patient adherence is critical with this therapy (Patil et al., 2007) Complying with this form of therapy could lead to social adjustment disorder for patients due to wearing a mask every night for the rest of their life (Knauert et al., 2015).

Charlson Comorbidity Index

The Charlson Comorbidity Index is a method of categorizing patients' comorbidities, and there are nineteen conditions in the index. The comorbidity is ranked from one to six, and the sum results in a score for patients. A higher score in the index results in mortality. Sleep disorders, like obstructive sleep apnea, are also a contributing factor in the index. The presence of comorbidities in patients adds health risks increasing their mortality rate in this index.

Obstructive sleep apnea is associated with diseases such as stroke, heart arrhythmias and cardiovascular diseases (Chiang et al., 2017). A direct relationship between patients with OSA and the Charlson Comorbidity Index could be identified if monitored in sleep labs. This association could further indicate that patients with

comorbidities and OSA may have a higher mortality risk than patients without the underlying comorbidities.

Positive Airway Pressure (PAP) Therapy

OSA is traditionally treated with CPAP therapy and is the gold standard therapeutic modality for moderate-to-severe OSA (Avellan-Hietanen et al., 2020; Boon et al., 2018; Mehrtash et al., 2019; Shapiro, 2021; Spriggs, 2015; Sturm et al., 2019; Woodson 2018). CPAP employs the use an internal compressor to generate pressurized room air, which is measured in centimeters of water pressure or cmH_2O, at a 21% oxygen concentration. Supplemental oxygen may be added to the system in accordance with a prescribed liter flow. This generated pressure then delivers the purified air to produce upper airway opening via a tubing system connected to a mask interface. In turn, the pressurized purified air is subjected to the upper airway to optimally treat the patient's apneic episodes during sleep (Spriggs, 2015).

Home PAP machines are a crucial component to treatment adherence, as the patient must first understand how to utilize their PAP device if they wish to continue using it for long-term therapy. Most home machines today incorporate memory or Wi-Fi capabilities for data storage and upload. In doing so, sleep medicine practitioners can obtain an accurate, detailed report of how patients are utilizing their CPAP machines on a nightly basis, such as average use over a 30-day period. Undoubtedly, this technological capability has significance in terms of follow-up appointments that are scheduled to ensure that patients are adherent to therapy, as well as if that therapy is optimally treating their sleep apnea. Examples of such monitoring services with remote connection capabilities to their brand of CPAP devices include Philips Respironics Care

Orchestrator, produced by © Koninklijke Philips N.V., 2004 – 2021 and ResMed AirView™, produced by © ResMed, 2019.

Moreover, the pressure setting, and mode of ventilation programmed within the home device has significance in their effects on PAP therapy adherence. The type of PAP machine, prescribed pressure setting, and mode of ventilation that is suitable for one patient may not be as applicable for another (Spriggs, 2015). Auto-PAP therapy provides an auto-adjusting pressure that modifies the generated pressure on an as-needed basis in correlation to decreased or absent airflow detected by the device (Spriggs, 2015). In turn, this auto-adjusting pressure setting has been shown to anecdotally promote patient comfort and improved adherence, although this has not been confirmed by randomized controlled trials (Mehrtash et al., 2019). Despite this, a recent retrospective analysis (n = 128,037) posits that PAP adherence rates were significantly improved (p <.0001) when utilizing an active patient engagement (APE) instrument in comparison to a usual care monitoring (UCM) database (Malhotra et al., 2018). This supports the notion that technological advancements will continue to play a significant role in improving overall PAP adherence rates, and newly graduated sleep technologists will be at the forefront of this shift in technology over time.

Selecting a mask type preferrable to the individual patient and proper mask fitting are both crucial components of promoting adherence to therapy. These actions are initiated and conducted by the sleep technologist performing the patient's initial titration study. Thus, a patient's first experience with PAP therapy, as well as how that experience will further influence long-term adherence, is often dependent upon the sleep technologist. Mask technology has advanced over the years to include nasal cushions,

which are interfaces that seal around the outside of the nose, and nasal pillows, which are interfaces that seal underneath the nares, oronasal or full-face masks (Mehrtash et al., 2019). There is no universal mask interface that will properly fit every patient, and for this reason, appropriate fitting performed by the sleep technologist is vital to long-term adherence.

Heated humidification is also a core component of PAP therapy and may prove significant in improving overall adherence in individuals. A primary side effect of PAP therapy is oronasal dryness extending to the upper airway that is induced by continuous airflow (Spriggs, 2015). Through humidification, these side effects are reduced, and overall patient comfort is often increased as a result (Mehrtash et al., 2019). Therefore, the sleep technology identifying which patient would benefit from heated humidification may promote long-term adherence to treatment. However, it should be noted that research is conflicting in the claim that heated humidification outright improves PAP adherence, despite its documented benefits in reducing some unwanted side effects of PAP implementation (Mehrtash et al., 2019).

PAP Therapy Adherence

With PAP therapy considered a first-line therapeutic option for reducing the subjective symptoms and objective comorbidities of moderate-to-severe OSA, it is imperative that patients become adherent to wearing their PAP devices nightly. Optimal PAP adherence, or compliance, defined by the Centers for Medicare and Medicaid Services (CMS) as a mean of ≥ 4 hours of use for ≥ 70% of nights, is essential in improving patient outcomes and should be a primary focus of all sleep education programs for this reason alone (Kakkar & Berry, 2007). However, the inability to

properly acclimate to PAP therapy has limited its use as a nightly treatment regimen for OSA in select patients. Therefore, further training of prospective sleep technicians regarding PAP adherence is warranted and may prove beneficial to the patients they serve.

Despite advancements made in PAP therapy over the years, as many as 50-60% of patients were noted as being unlikely to adhere to long-term therapy in one meta-analysis (Ratneswaran et al., 2021). Additional research has reported that approximately 70% of first-time PAP therapy users will continue to use therapy after one year (Avellan-Hietanen et al., 2020). In turn, this suggests the troubling notion that one-third of PAP-naïve patients will discontinue compliant nightly use of their PAP devices after only one year. Overall adherence rates of PAP therapy were found to be extremely variable within the literature from 29-83%, and adherence was noted to significantly decrease after only one year of use (Boon et al., 2018; Huntley et al., 2018). Thus, long-term therapy compliance extending beyond the first year of use requires additional intervention of the sleep medicine practitioner to ensure that adherence is maintained.

Several factors and predictors, including bed partner, age, gender, race, socio-demographic characteristics, and disease severity, have been studied to predict if any will or will not affect PAP adherence. By determining an association of PAP adherence variables and improving patient adherence, patient care, and the overall quality of life of these patients, can be improved.

The level of PAP adherence varies considerably across the patient population but it is averagely suboptimal. The breadth of risks factors and possible predicators for PAP non-adherence is quite broad and unique to each population group, geographical location,

demography, and individual patient (Van Ryswyk et al., 2019). The majority of PAP compliance delimiting factors fall into five broad categories including but not limited to psychosocial, biomedical, and technological factors. Biomedical factors are largely confined to disease and symptoms severity and adverse PAP side effects. Self-reported PAP side effects with statistically significant impediment on compliance include dry airway, claustrophobia, inconvenience due to noise and sleep problems, mask discomfiture, eye sores, and mask leaks (Catcheside, 2010). Confounding psychological-related factors are largely magnified and modulated by patient cognitive behavior, lack of social support, low socioeconomic status, and depressive disorders. The convergence of predictive factors especially deficient education and experience, patient attitude and expectations, suboptimal initial use of PAP, demography, and psychosocial and behavioral barriers has long term effect on PAP compliance (Sawyer et al., 2011, Lettieri & Walter, 2013; Guralnick et al., 2017; Lundqvist et al., 2019;). Slow advancement in PAP technologies further diminishes PAP adherence in part due to limited PAP alternatives and infinitesimal variances in patient experiences. By determining an association of PAP adherence variables and improving patient adherence, patient care, and the overall quality of life of these patients, can be improved.

Disease Severity

Disease severity, which is often measured by the apnea hypopnea index (AHI) and nocturnal hypoxemia in sleep labs, may play a role in PAP adherence. The AHI is the number of apneas and hypopneas recorded during the sleep study per hour of sleep. Based on the AHI, the severity of OSA is classified as follows:

- None/Minimal: AHI < 5 per hour

- Mild: AHI > 5 but <15 per hour
- Moderate: AHI > 15 but < 30 per hour
- Severe: AHI > 30 per hour (Thornton et al., 2012)

Prior study results are inconsistent with these variables once again. While studies suggest that patients are more adherent to PAP when their OSA is more severe, others suggest no correlation between the two variables (Engleman et al., 1996). A large study conducted by Kohler et al. (2010) concluded that of 639 patients, severity of OSA determined adherence to the CPAP therapy. They further explained that the hypopneas recorded (HR) of 0.97 for oxygen desaturation index (ODI) indicated an increase of ten in ODI, which is linked to a risk reduction of 26% for not adhering to PAP (Kohler et al., 2010). Kohler et al. concluded that the PAP adherence was 81% after five years and 70% after 10 years respectively, and patients used it for 6.2 hours/night on average. A contradicting study of 112 newly diagnosed OSA patients concluded that no correlation existed between the severity of OSA and PAP adherence (Huntley et al., 2018). The authors concluded that frequent apneas were associated with better adherence at one month after initiating CPAP with a $p = 0.039$, but not at three months with a $p = 0.22$ (Huntley et al., 2018).

Excessive daytime sleepiness (EDS) is a critical side effects of untreated OSA and often a determinant of PAP adherence. The Epworth Sleepiness Scale (ESS) can easily measure EDS. The ESS is a self-administered questionnaire with eight questions (see Appendix B). Respondents are asked to rate, on a 4-point scale (0-3), their usual chances of dozing off or falling asleep while engaged in eight different activities. Most people engage in those activities at least occasionally, although not necessarily, every day. The

ESS score, which is the sum of the eight questions scored 0-3, can range from 0 to 24. The higher the ESS score, the higher that person's average sleep propensity in daily life (ASP), or their 'daytime sleepiness' (Epworth Sleepiness Scale, n.d.).

Deaths From OSA

According to the Centers for Disease Control and Prevention (CDC), deaths due to OSA commonly occur due to the associated diseases (2021). The disease is hazardous for people with the sleep disorder condition. Some of these diseases are preventable and thereby require care to ensure control and eventual prevention of occurrence. The chronic diseases that cause death due to OSA include heart disease, stroke, type 2 diabetes, arthritis, mental disorders, and lung infections (Coté et al., 2014). Chronic diseases are the leading causes of death associated with OSA within the United States. The diseases can sometimes result in permanent disability in situations where they do not cause death. According to the CDC, there are six critical causes of chronic diseases that affect the United States population (Du et al., 2018). Of the chronic infections linked to OSA, cancer accounts for 10.6 million deaths or 3.6%, diabetes causes 13.7 million deaths or 4.7%, and heart disease causes 19.1 million deaths or 6.6% of the deaths. Other conditions, such as hypertension, are also significant causes of death within the United States. The total reported cases of chronic diseases within the United States equaled 162.2 million or 55.8% of the population, with pulmonary disease-related conditions ranking the highest. (Subramani et al., 2017).

According to Bodenheimer et al. (2009), the Office of Health Affairs posts that approximately 133 million U.S. citizens were afflicted and suffering from at least one chronic health condition in 2009. Moreover, it was predicted that by 2020, more than 167

million individuals will have been afflicted and suffering from a single chronic illness. Individuals living with multiple chronic illnesses or health conditions in 2009 exceeded sixty-three million, and it is further estimated that the number of U.S. citizens suffering from multiple chronic health conditions will meet, or surpass, eighty-one million by the year 2020 (Bodenheimer et al., 2009; CDC, 2021). The American Sleep Apnea Association approximates 38,000 deaths per year due to heart disease that contains the sleep apnea complication (American Board of Sleep Medicine, n.d.). The disorder has the potential to get undiagnosed, and with continued long-term reoccurrence, it could lead to a possibility of death.

According to Ong & Crawford(2013), OSA has the potential of causing death among individuals, as indicated by the previous research related to the sleeping disorder. The deaths can cause an economic burden on the country, leading to a decline in the country's economic situation (Ong & Crawford, 2013). Developing policies that can help mitigate the chances of having chronic conditions that can result in death is essential (Ottaviani & Buja, 2020). The OSA-associated conditions can be prevented eventually due to the control measures put in place to mitigate the effect of the diseases. Indeed, there is enough evidence to show that OSA causes death due to the data illustrated from America and other countries (Marshall et al., 2008). Exercising preventive measures that help reduce the impact of the sleep disorder is vital. OSA affects both children and adults, and thus every group needs to be considered in the fight against the disorder.

Socio-Demographic Characteristics and OSA

Patient characteristics of relevance include age, gender, race, and socioeconomic status, yet dearth amount of data is available nor consistent in associating these factors

with adherence. Disparities are also noted between chronic disease and health conditions for individuals living in poverty or within underserved areas (Billings et al., 2021). Disparities in sleep health are often underrecognized in comparison to the overall health disparities. The vivid understanding of the factors that contribute to sleep health disparities help in the improvement of the quality of an individual's health. Socioeconomic status, discrimination, geography, and social patterns are some of the impacts of sleep health disparities, especially OSA (Carnethon et al., 2016).

Few studies have focused on comparing the prevalence of OSA across various racial groups. Again, there is a lack of consistency in defining the OSA limits across the numerous studies. Available data indicates a high prevalence of OSA in African Americans and Hispanics compared to Caucasians (Dudley & Patel, 2016). From the evidence, there is a substantial racial disparity regarding African Americans compared to any other group. In the number of the pediatric children evaluated in the sleep centers, African American are associated with an increase of over 20% in the severity of sleep apnea (Dunietz et al., 2021). In the middle-aged population, the prevalence in disparity is weaker, according to community-based studies. In a survey based on the community, people 65 years old and above are 2.1 times more likely to have severity in OSA (Dunietz et al., 2021). However, there is scarce information about OSA among Native Americans (Laposky et al., 2016). Unlike the prevalence in African Americans and Hispanics, Asians have a lower prevalence than Caucasians. However, when comparing the prevalence between Japanese and Caucasians, Japanese have a lower prevalence of 18.4% compared to 36.5% for Caucasians. Other studies indicate that the prevalence for Caucasians and Asians is the same (Williams et al., 2015). According to the Male Study

of Osteoporosis for older men, there is evidence that the Asian American background is a very independent risk factor in sleep disorders (Williams et al., 2015). The evidence is consistent with the population-based studies originating from Asia, which indicate higher rates of OSA in Japan, China, and Korea, even with the small number of obese people in the countries. Therefore, there are significant disparities that exist from one region to another. The geographical location and morbidities determine the disparities that are present in the different areas across the globe.

Socioeconomic factors, such as income and education level, may play a role in PAP adherence. According to Simon-Tuval (2009), a study with 162 OSA patients, patients who made > 120% of the average income of the study sample had an increased odds of PAP adherence, defined as ≥4 hours/night) compared to those who made less than 80% of the average income (Simon-Tuval et al., 2009). Moreover, cost may be a reason for patients not adhering to PAP therapy. According to Gulati et al. (2017), out of 265 OSA patients, only 21% of the patients with low income accepted and purchased the PAP device, compared to 51.4% of those with an average income, and 75.6% of those with higher income.

Naghavi et al.'s (2019) research involving the study of medical adherence indicates that adherence to medical treatment today is multifaceted and depends on factors including socioeconomic issues, individual-related aspects, features of health service providers, therapy-related situations, and disease characteristics. Individual-related factors that affect compliance entail age, gender, literacy level, job type, marital status, ethnicity, belief, attitude towards medication, and behavior (Naghavi et al., 2019). Butterworth et al. stated that patients who can read and understand treatment instructions

on medication labels always have better compliance as opposed to those with low health literacy, who are likely to non-adhere to treatment (as cited in Naghavi et al., 2019). Age is also a crucial adherence factor. The same study highlights that at an advanced age, individuals tend to have memory, hearing, and vision problems that may result in failing to meet therapy adherence.

Socioeconomic Factors and OSA

Whereas OSA itself is not acutely threatening to life, it is associated with other severe complications, including cardiovascular and metabolic diseases and hypertension or high blood pressure, if left untreated (Morsy et al., 2019). Whichever the extent, OSA disrupts workplace performance in several ways, including sleepiness during the daytime and is also associated with workplace injuries due to accidents (Morsy et al., 2019; Rodenstein, 2009). Treatment of OSA and related diagnosis would imply that a patient is likely to decrease their earnings because of the medication expenses. Similarly, society and the health systems may incur costs beyond an individual's healthcare budget. For instance, in the study by Morsy et al., OSA was associated with a significant healthcare financial burden due to its high prevalence of associated morbidities and complications. The study found that the cost of healthcare utilization depends on the severity of OSA, and more often, OSA patients are heavy users of hospital services even before the diagnosis for OSA. Prior knowledge of OSA and its proper management would reduce healthcare costs, benefit the patient, and improve work productivity, which would be beneficial to improving aspects of society.

The awareness of these risks and treatment with PAP technologies protect the larger community from these risks. Driving is one of the professions that is usually

affected by OSA. Furthermore, people drive to workplaces, and therefore, driving is a contributing factor to the economy. In a study aimed at screening professional drivers for sleep apnea in 2009, out of the 1400 drivers with commercial licenses who were screened, 13% were recommended for polysomnography following the set criteria on body mass index, suspicion of OSA on Epworth Sleepiness Scale (ESS), and neck circumference. Seventy percent of this population underwent polysomnography, and 95% of the participants screened showed OSA (Rodenstein, 2009). These numbers imply that OSA complications might cause several accident cases. In a study by Morsy et al. (2019), it was concluded that medical conditions including hearing and vision impairment, diabetes, arthritis, and alcoholism increased the rate of traffic accidents by 20 to 100%. However, OSA had the highest risk of 3.71 behind road accidents due to age and gender. These OSA-related accidents and general inefficiency have implications on costs in any workforce, including productivity costs, insurance-related costs, healthcare costs, and health workers' reimbursement costs. Morsy also notes the excess costs due to OSA trickle down from non-attendance to work (2.63 times more), more cardiovascular medication costs (1.9 in excess), hypertension (2.7 times more), and increased hospital stay.

According to Palm et al. (2021), the healthcare-cost burden witnessed by the patient and the implication of OSA on society has an impact on the severity of OSA, and it is also a risk factor for CPAP acceptance among adult patients (Papadopoulos et al., 2018**;** Simon-Tuval et al., 2009). According to Simon-Tuval et al., socioeconomic status within a neighborhood, educational levels, and income are key factors influencing adherence to CPAP treatment in OSA patients and can be regarded as strong predictors

for treatment adherence. Studies conducted by Palm et al. associated poor compliance with low-income levels and highlighted patients' inability to afford the treatment device as a partial explanation. These findings are opposed to the Swedish healthcare system, where health is primarily funded via taxes, enabling patients not to rely on private healthcare insurance and the private economy to access CPAP treatment (Palm et al., 2021). Palm et al. presented that less time observed among patients using CPAP and BiPAP in the United States and New Zealand may have been related to their low incomes. Therefore, the level of education and income are critical factors in OSA treatment using CPAP. As highlighted in *Healthy People 2030*, low socioeconomic status negatively impacts health and life expectancy (Office of Disease Prevention and Health Promotion, n.d.). Therefore, when managing patients with CPAP, it is crucial to develop a greater awareness of the repercussions of non-adherence tailored to the patient's socioeconomic status. Where necessary, it would be wise to adopt a follow-up on a patient and determine ways to improve CPAP or BiPAP treatment compliance.

Financial Burden of Sleep Disorders

Sleep disorders, like other diseases, influence the economy. Garbarino et al. (2016) reported the direct health costs of sleep disorders alone were $146 million. Adults develop health conditions that include chronic diseases and other incidences. Short sleep duration of fewer than seven hours a night has a high association with cardiovascular morbidity and associated metabolic disorders such as glucose intolerance. The additional cost of the associated conditions, such as cardiovascular disease, diabetes, depression, and work-related accidents, was $313 million (Garbarino et al., 2016). Cardiovascular disease specifically was $30 million, while diabetes alone was $21 million (Hillman et

al., 2018). According to research done in Australia for 2018-2020, the rough financial cost of inadequate sleep within the budget year was $45.21 billion (Hillman et al., 2018). For the same year, the financial cost component was $17.88 billion comprising direct health costs at $160 million with $1.08 billion for the associated conditions of sleep disorders. In the same year, productivity declined by $12.19 billion, with a breakdown of $5.22 for reduced employment and $1.73 billion for absenteeism. The non-medical accident costs were $2.48 billion, with $41 billion accounting for informal care and $1.56 billion on deadweight loss (Hillman et al., 2018). The Australian research results indicate that the financial losses associated with sleep disorders are substantial in nature and quantifiable (Hillman et al., 2018)

Further research performed by Hafner et al. (2017), between 2016-2017 for a population of 25.5 million people indicated that the overall cost for sleep disorders was $35.4 billion, with a whopping $13.1 billion associated with OSA. Of the cost, $10.0 billion was associated with the health system costs, while $7.7 billion related to productivity losses due to the sleep disorder. The study found out that people with sleeping disorders were highly unproductive and had a low contribution to the general productivity of the country (Hafner et al., 2017). Money was lost in treating the condition, along with people suffering to self-sustain productive lives. Patients diagnosed with OSA made the highest financial losses, according to both the studies done in Australia (Hafner et al., 2017).

Every country loses money due to the attempt to control the sleep disorder (Ong & Crawford, 2013). Therefore, the government accounts for health budgets that help control the sleep disorder for patients with such conditions. It is essential for every

country to recognize the disorder and do the appropriate budgeting related to the containment of the condition. The financial implication of sleep disorders means that every government has a responsibility to develop corrective measures and adopt ways that help reduce the effects of sleep disorders, especially OSA. To overcome the challenges of the disorder, every government must develop a proper plan to accommodate the population with OSA (Huyett & Bhattacharyya, 2021). Families also incur financial costs in the attempt to help the members with sleep disorders. Families could face the financial burden of the patient's treatment, including PAP devices. In severe conditions, the cost burden for a family is so immense that it can plunge the family members into loans (Streatfeild et al., 2021). At times, the maze of health insurance gets exhausting when dealing with sleep disorders; however, the financial burden of the disorder ranges from country to country.

Secondary Sleep Problems

Sleep disorders can be categorized as primary or secondary. According to the Suni (2021), primary sleep disorders are not attributed to any existing environmental, psychiatric, or medical causes like pain, medication, and drug abuse. On the contrary, secondary sleep disorders arise from other sleep disorders, mental disorders, and preexisting medical illnesses. Although there are more than seventy distinct types of sleep disorders, most can be placed into three categories: insomnia, obstructive sleep apnea, and excessive sleep (Hirshkowitz, M., Whiton, K., Albert, S., Alessi, C., Bruni, O., & DonCarlos, L. et al, (2015). Sleep disorders are known to affect the body negatively in terms of metabolic processes as well as immune functions (Ong & Crawford, 2013). It is suggested that the reason for the decline in the average amount of

sleep and some sleep disorders can be accredited to more distractions at nighttime due to technology and a higher-strung work ethic (Stamatakis et al., 2007). A growing concern about the lack of recommended sleep is attributed to a fast-paced society, socioeconomic factors, and/or sleep disorders. A sleep study done by the National Sleep Foundation indicates that for young adults and adults, the recommended sleep duration should be seven to nine hours; for older adults, the recommended sleep duration should also be seven to nine hours (Hirshkowitz, M., Whiton, K., Albert, S., Alessi, C., Bruni, O., & DonCarlos, L. et al. (2015),Fifty to 70 million Americans suffer from some type of sleep disorder, and 25% of Americans report the inability to obtain adequate sleep 15 out of 30 nights (Hirshkowitz, M., Whiton, K., Albert, S., Alessi, C., Bruni, O., & DonCarlos, L. et al, (2015)

Insomnia can be a comorbid or primary condition, and it is likely for physicians to assume the underlying primary conditions for symptomatic insomnia (Sateia, 2014). Most chronic insomnia illnesses share many characteristics, regardless of whether it is comorbid or primary (Sateia, 2014). Secondary to OSA are comorbid insomnia, nighttime and daytime nocturnal symptoms, restless leg syndrome, and brain impairment (Luyster et al., 2010; Ong & Crawford, 2013; Pagel, 2009). Evaluating and screening for secondary sleep disorders in OSA would help improve the diagnosis and treatment necessary for OSA.

Ong and Crawford (2013) posit that most patients do not know about the classification of sleep disorders or even their comorbidity. Therefore, doctors are likely to rate comorbidity depending on the chief complaint. However, the attribution between insomnia and OSA is highly prevalent and is associated with significant morbidity.

Therefore, sleep technologists need to conduct comprehensive assessments for insomnia and OSA regardless of the complaints presented. Further, management should consider both conditions. In most studies, insomnia symptoms can be used to predict OSA and can also impact effective assessment and treatment negatively (Ong & Crawford, 2013). Therefore, comprehensive care for patients presenting both insomnia and OSA cases is necessary.

According to Luyster et al. (2010), OSA severity was co-linked with insomnia as a symptom, but the reverse was not true in the study conducted on 255 patients who underwent assessments for possible OSA (Kapur as cited in Luyster et al., 2010). Most of these patients, 54.9%, reported at least an insomnia complaint, including difficulty initiating sleep, difficulty managing sleep, and premature awakenings. Half of this sample complained of both insomnia and hypersomnia. It is crucial to improve adherence to CPAP and BiPAP in OSA patients that complain of insomnia symptoms. For patients who have difficulty sleeping or maintaining sleep, Luyster et al. recommend using hypnotics to initiate PAP treatment since it could improve adherence. This study needs to incorporate the concept of secondary sleep disorders in gaining knowledge that would help manage and treat OSA patients presenting insomnia comorbidity. It is crucial to understand the potential impact of comorbid insomnia on PAP treatment therapy to facilitate long-term management of OSA problems in patients with secondary insomnia.

Social Burden and OSA

Within the United States, chronic illness such as diabetes, heart disease, and high blood pressure are steadily increasing, with a higher prevalence noted in underserved, minority, and low-income patient population areas (Holman, 2020). The sequalae of

multimorbidity reduces a person's quality of life, results in poorer health and health outcomes, and increases the financial burden to the country's already unaffordable, unsustainable, healthcare system (Holman, 2020).

Patients with OSA undergo excessive daytime sleepiness that usually persists without the treatment of the disorder. As a result of the excessive sleepiness, there is a decreased quality of life for the patients that affects their general day-to-day functionality (Léger & Stepnowsky, 2020). Excessive daytime sleep (EDS), or hypersomnolence, refers to the urge to sleep during the hours in which one is expected to be awake and performing duties. EDS is often a social sign of OSA that affects the patients' ability to travel, work, and enjoy life in all aspects (Jennum et al., 2013). However, it is also possible that EDS may or may not be a predominant factor in a OSA diagnosis.

Excessive daytime sleepiness is a common worry for most patients with OSA. Most of the patients that demonstrate OSA feel the impact of social stigmas associated with the disease (Bajraktarov et al., 2011). There is a burden that OSA patients must carry concerning the association with peers and different people. People often sleep in meetings within the workplaces leading to a lack of task completion. OSA hinders the understanding of critical concepts because patients often have limitations in terms of attention (Léger & Stepnowsky, 2020). The patients may fear engaging in social activities because of being stereotyped by their peers.

According to Léger and Stepnowsky (2020), EDS limits patients within their social life. With this disorder, people's general productivity gets minimized since most time is spent sleeping or napping instead of engaging in activities that have economic benefits. In workplaces, supervisors may chastise people with the tag name of being lazy.

The constant urge to doze affects daily activities of life. Sleep becomes a constant distraction for the patients in everyday activities and life events (Léger & Stepnowsky, 2020). A wide variety of demographic factors may influence sleep duration. Specifically, short sleep duration can be attributed to patients who are older, female, taking care of children, and/or low socioeconomic status (Chaput & Sampasa-Kanyinga, 2018).

Factors that lead to longer sleep duration have been found to include supportive marriages, unemployment, and long work hours (Krueger & Friedman, 2009). Krueger and Friedman concluded that insufficient sleep duration was commonly found in the proportion of households with the lowest income and in people who have below a high school education. Short sleep duration was found more in African Americans and Hispanics than Caucasians (Stamatakis et al., 2007). Studies indicate that Asians reported the fewest complaints about sleep quality. Caucasians reported more sleep quality complaints than Hispanic/Latino and Black/African American Individuals (Kruegar & Friedman, 2009). An individual's specific situation may play a significant role in sleep duration depending on the context (Stamatakis et al., 2007). Alcohol is another factor that affects sleep. An experimental study conducted by Koob and Colrain (2019) indicates that consuming alcohol before sleeping may result in sleep-disordered breathing. This showed more of a risk in men than women (Koob & Colrain, 2019).

Psychosocial Factors and PAP Adherence

Psychosocial factors are also responsible for a significant role in PAP non-adherence. These influences may include psychological variables, such as health locus of control and self-efficacy, the presence or absence of a constructive social support system within the patient's home environment, as well as the degree of involvement from the

patient's bed partner (Mehrtash et al., 2019). A social support system within the patient's household that provides a focal point on general well-being will be more apt to hold that patient accountable to their various treatment regimens. To facilitate long-term compliance, persistent support provided to the patient at home may be indispensable to promote nightly PAP therapy use (Shapiro, 2021).

Moreover, socioeconomic status is a significant predictor of compliance, as it is a combination of the income and education levels of the patient. More specifically, a lower socioeconomic status has been associated with a poorer degree of health literacy, or the capacity to understand health-related concepts and treatments (Mehrtash et al., 2019). Patients who are unable to comprehend why they require PAP therapy are at an increased risk for becoming non-adherent simply due to a lack of understanding. As such, it is paramount that the sleep medicine practitioner not only provides care for each patient in terms of treating OSA, but also provides tailored education depending upon each patient's individual needs and level of understanding. Similarly, an increased income level has been correlated with improved adherence (Mehrtash et al., 2019). This relationship is often explained by enhanced access to healthcare services and the ability to pay for such services with more monetary income.

Circumstances, such as anxiety regarding the therapy or claustrophobia secondary to mask fitting, are additional factors that must be considered when analyzing PAP non-adherence. These factors may also inadvertently alter a patient's personal beliefs regarding PAP therapy, including that the intervention may not be beneficial to them or their health because they are unable to overcome these apprehensions. Research supports the notion that anxiety is a potent predictor of PAP therapy adherence, as decreased

psychological status in the form of anxiety has been expressed alongside other OSA symptoms and comorbidities (Shapiro, 2021). Consequently, anxiety-reduction strategies may prove useful during an initial PAP titration study within the sleep laboratory setting, as these efforts may transfer to the patient's home environment.

Personal Health Risk Behaviors

Insufficient sleep has serious health consequences on individuals. Adults, youths, adolescents, and children can be affected by the lack of sleep. Substantial evidence supports the health risk of adults who do not get enough sleep (Hildenbrand et al., 2013). The disorders can cause obesity, heart disease, diabetes, and hypertension (O'Brien & Mindell, 2005). Individuals with sleep apnea have a 1.48 times greater risk of developing coronary heart diseases than those who do not suffer from OSA (Perry et al., 2013). They are also very susceptible to stroke conditions.

Sleep disorders affect immunological function that relates to mood disorders. Patients with such conditions suffer from depression and cognition deficits that have a high effect on reduced life quality. Adults who sleep for less than seven hours a night have a short concentration span and struggle to perform the daily activities that constitute the varied aspects of life (Owens, 2014). Children who have sleep disorders have been shown to have low performance in classes, impaired behavior, and bad mood swings (Suni, 2021). Daytime sleepiness reduces alertness and results in a slow reaction time. There are chances of occupational errors and additional workplace injuries with sleep deficit.

Adherence and Medical Treatment Today

Health adherence is the process that entails following the set regulations, rules, and laws that relate to healthcare practices. Non-adherence with medication or treatment is a key reason for preventable deaths and economic burden. To improve the issue for stakeholders and policymakers, physicians and other medical specialists must recognize the factors leading to non-adherence to treatment measures from the perspectives of both patients and healthcare providers.

Another factor that is identified to affect medication adherence is belief. According to Naghavi et al. (2019), "belief is a cognitive aspect that entails patient knowledge, health literacy, religious belief, decision-making attitude, and previous experience. Some people may become hesitant to following doctors' recommendations after consulting with other people" (p. 13). Also, the culture of a community from which a person comes may lower their adherence. For example, people's cultural customs may be against therapies prescribed by a doctor, and in some cases, religious beliefs may make one dependent on miracles and healing rather than the treatments prescribed by doctors (Naghavi et al., 2019).

Pluta et al. (2020) focused on acceptance of illness and adherence with medications in patients with hypertension in Poland. The findings revealed that an adherence score was better with a higher level of education, lower in men, and reduced in groups with low comorbidities. Socio-demographic factors, like education and sex, influenced adherence, whereby women showed a higher adherent level of 6.78 against 6.08 for men ($p < 0.001$). The same adherence level was reported in those with the highest level of education. Non-adherence with medication is detrimental to society and

the economy. Therefore, such an issue of non-adherence should alert the medical staff, policymakers, and other stakeholders to organize an awareness to sensitize the public about health medication and therapy adherence. Policymakers and health professionals should understand the multidimensional factors that affect medication and treatment adherence and consider them when designing programs to enhance treatment adherence. Education and awareness about a disease and its treatment techniques can help enhance the knowledge and health literacy of the public. Doctors and healthcare professionals should know how to approach people with low health literacy, using strategies such as:

- using non-medical simplified language
- repeating information
- speaking slowly
- utilizing learning methods
- communicating to gain patient trust
- enhancing patient participation
- engaging them in designing treatment plans to reduce non-adherence

The information above would be crucial to add to a body of knowledge for this study and would be necessary to utilize for treatment adherence in patients utilizing PAP therapy for OSA. First, the OSA patients must be guided into acceptance of their medical condition. This can be achieved by engaging psychologists who would be helpful to the clinicians to establish the patient's level of acceptance (Pluta et al., 2020). Further, Pluta et al. recommend that medical and pharmaceutical personnel be trained on information technology and how to communicate with patients effectively. This effective

communication enables patients to comply with therapeutic recommendations to reduce the comorbidity risks associated with the disease.

Cost of Missed Follow-Up Care

A study by Dowdy et al. (2011) established that failure to plan for a timely follow-up appointment was detrimental to continuity and quality healthcare, particularly for patients in a low-socioeconomic class or those with low-health literacy. Missed follow-up care implies missed appointments and can be instigated by either the patient or a weak healthcare follow-up system. The study by McQueenie et al. (2019) found that people with long-term conditions who miss primary follow-up care services may be at risk of premature death. People with multi-morbidity were likely to miss primary care scheduled appointments. In a representative Scottish sample, 46% of patients who missed one or two appointments had more than one long-term condition, whereas 17% of missed appointments were patients who had more than four long-term conditions. The study established that repeated missed follow-up care was associated with increased premature mortality rates, specifically among patients with long-term mental health conditions. Patients with long-term physical health conditions who missed at least two follow-up care appointments per year showed three times more of an increase in premature mortality than those who did not miss any scheduled appointments (McQueenie et al., 2019).

In the United States, missed healthcare appointments cost an overwhelming $150 billion annually (McQueenie et al., 2019). This figure is achieved from the no-show follow-up rate that is as high as 30% and leads to an unutilized time slot that costs a practitioner 60 minutes and approximately $200 on average. Healthcare providers try to reduce these costs by establishing high-tech, digital reminders at the patients' and

physicians' disposals, but the outcome is still negative. Missed appointments and follow-up care in patient medication pose serious health risks and can be fatal. Therefore, there is a need to set measures to reduce the costs due to missed appointments and follow-up care. The tips suggested by the Health Care Innovation Group include providing a streamlined experience for patients to book and preserve appointments, assuring complete and smart scheduling to optimize capacity and utilization, and offering unmatched convenience that eliminates delays and difficulty in healthcare (McQueenie et al., 2019). A fast and streamlined experience offers a centralized system of scheduling across all facilities. Smart scheduling can be achieved by automating the rules to maximize patient and resource scheduling. Lastly, convenience for providers and patients is achievable via self-scheduling, appointment reminders, and integrated insurance authorizations. All the above factors also affect non-adherence to treatments in sleep clinics and centers.

Disasters Influenced by Sleep Deprivation

According to Medic et al. (2017), sleep deprivation refers to having inadequate or insufficient sleep leading to constant or excessive sleepiness. Sleep deprivation is characterized by poor sleep quantity and quality needed to support the body's optimal health, alertness, and performance (Medic et al., 2017). Sleep deprivation can be caused by sleeping at the wrong time of the day, not sleeping well, or by sleep disorders causing mediocre quality of sleep. Sufficient sleep is vital for maintaining brain functions and physiological processes. Sleep deprivation has significant adverse short-term and long-term effects, such as somatic pain, mediocre quality of life, emotional distress, and decline in performance (Medic et al., 2017; Peng et al., 2020). In the workplace, lack of

sleep is a safety issue that affects cognitive and memory impairment and slows reflexes. Sleep deprivation has been associated with workplace accidents.

Previous investigations have associated sleep deprivation with the 1979 nuclear accident at Three Mile Island. Sleep loss and fatigue played a role in influencing the inability of the plant operators to recognize the plant reactor's faulty status before the event (Suni & Singh, 2021). Another accident linked to sleep deprivation is the 1986 Chernobyl nuclear disaster in which reactor power surges led to radioactive explosions. According to Suni and Singh, investigators of the accident concluded that long-hour shifts, working at night, tight schedules, and deadlines influenced drowsiness and fatigue that led to the accident. Particularly, 13-hour long shifts were established to significantly contribute to human errors that led to the explosion (Suni & Singh, 2021).

The explosion of the Space Shuttle Challenger and the grounding of the Exxon Valdez oil tanker also occurred due to sleep deprivation (Suni & Singh, 2021). The Shuttle Challenger accident killed astronaut crew members and jeopardized the multi-billion-dollar shuttle program. On the other hand, the Exxon Valdez oil spill disaster caused indeterminable environmental, ecological, and financial damage. In both accidents, it is understood that the individuals taking control of the operations were expected to make crucial decisions while working under highly sleep-deprived conditions (Suni & Singh, 2021). Therefore, sleep deprivation and fatigue indirectly influenced the accidents.

Another accident known to be influenced by sleep deprivation was the American Airlines Flight 1420 crash during the attempt to land in Little Rock, Arkansas. Although this crash occurred during a thunderstorm, the report by the National Transport Safety

Board (NTSB) showed that the pilots were under extreme sleep deprivation and fatigue to land safely, in addition to the severe weather conditions (Suni & Singh, 2021). These were reported to lead to mistakes that resulted in the plane veering off the runway leading to fatal outcomes.

Another accident influenced by sleep deprivation was the 2015 Metro-North train crash. A New York commuter service train hit an SUV that had parked on the rail tracks, causing wreckage and fire in the front carriage. This led to the deaths of several people, and others were injured. Investigations by the NTSB led to the conclusion that the accident was caused by an undiagnosed case of sleep apnea, which made the Metro-North Railroad engineer fall asleep as the train rounded a sharp curve (Haynes, 2017). It was believed that the situation was aggravated by the changes in the work schedule of the engineer, including early morning shifts that influenced drowsiness (Haynes, 2017). A similar incident was the 2016 Hoboken train crash believed to be influenced by an undiagnosed sleep disorder that caused the New Jersey Transit train to crash into the Hoboken terminal ("Engineer in Hoboken Train Crash Had Undiagnosed Sleep Disorder, Lawyer Says (Published 2016)", 2021). In all these cases, sleep deprivation significantly influenced the disasters.

Chronic Sleep Deprivation

Chronic sleep deprivation can affect aspects of one’s life, even a person's appearance. Over a period, the disorder can cause premature wrinkling with dark circles under the eye. There is an excellent relationship between insufficient sleep and a rise in stress hormones within the body (Owens, 2014). Cortisol, a stress hormone, breaks collagen, which is the protein responsible for smoothing the skin (Owens, 2014). Sleep

disorders tend to impact adults, adolescents, and children in an equivalent way. The disorder exacerbates mood disturbances like depression, anger, confusion, fatigue, and lack of vigor.

The result of a Buss-Perry Aggression Questionnaire for the assessment of verbal and physical aggression within a group of young male adults found out that the males who reported fewer sleep durations had problems with anger and aggression (Wheaton et al., 2016). The results of the research were analyzed with a sleep duration correlation. According to further research, there is a similar pattern of sleep deprivation that causes a change in the behavior and mood of the individuals in both females and males. The males studied were affected more by aggression when deprived of sleep than their female counterparts. On the other hand, females were more susceptible to mood changes when exposed to sleep deprivation (Saghir et al., 2018). The females also showed signs of low energy and brain fog when under sleep deprivation. In the case of children, there was an equal score for both males and females. However, the behavior presented externalizing behaviors like aggression and impulsivity coupled with very inappropriate social interactions.

Sleep Credential Overview

The Board of Registered Sleep Technologists (BRPT) professionally credentials registered sleep technologists. Since the first credentialing exam administration in 1979, the BRPT has credentialed over 22,000 RPSGTs in the United States, Canada, and thirty-two countries overseas (Board of Registered Polysomnographic Technologists, n.d.). Currently, the highest degree available in sleep technology is an associate degree; however, individuals can choose a certificate instead of an associate degree (American

Association of Sleep Technologists, n.d.). RPSGTs' scope of practice includes, but is not limited to:

- polysomnography
- patient management of PAP devices
- oximetry
- capnography
- actigraphy
- administering nocturnal oxygen
- utilization of screening devices
- involvement in sleep education efforts
- administering patient questionnaires
- laboratory management
- quality assessment
- research (American Association of Sleep Technologists, n.d.)

With international recognition, the RPSGT is recognized as the "gold standard" of credentialing in sleep medicine because it represents the highest certification in the field for healthcare professionals who clinically assess patients with sleep disorders. It gets complicated and convoluted due to other credentials established by different founding bodies fighting for the "gold standard" title. In 2014, the BRPT also launched the Certification in Clinical Sleep Health (CCSH) exam. The CCSH is an advanced credentialing examination for healthcare providers who work directly with sleep medicine patients, families, and practitioners. The healthcare providers coordinate and manage patient care, improve outcomes, educate patients and the community, and

advocate for the importance of good sleep (Board of Registered Polysomnographic Technologists, n.d.).

In 2011, the American Board of Sleep Medicine (ABSM) began offering a credentialing exam for sleep technologists. A sleep technologist examination committee comprised of senior members from the sleep technology profession and the sleep medicine field developed the ABSM Sleep Technologist Registry Examination. The examination is updated yearly to reflect the day-to-day responsibilities of the sleep technologist in a clinical setting. Successful candidates earn the Registered Sleep Technologist (RST) credential (American Board of Sleep Medicine, n.d.). ABSM's certificates are recognized throughout the world as a credential signifying a prominent level of competence for sleep medicine physicians, PhDs, behavioral sleep medicine specialists, and sleep technologists. The ABSM's objective is to promote excellence in medical care for patients with sleep disorders, and certification represents dedication to the highest level of professionalism in patient care. This added measure of expertise provides a standard of excellence recognized by the public, members of government, and regulatory bodies to identify skill, experience, and competence (American Board of Sleep Medicine, n.d.).

In 2012, the Respiratory Therapist Sleep Disorder Specialty (RRT-SDS) examination emerged and objectively measures the knowledge and skills of respiratory therapists who perform sleep disorder testing and therapeutic intervention. (National Board for Respiratory Care, n.d.). This exam goes beyond general respiratory care activities to focus on competencies that are unique to diagnosing and treating sleep

disorders. The RRT-SDS signifies experience and education in the field of sleep medicine (National Board for Respiratory Care, n.d).

Sleep Education Programs Today

Today, sleep education programs are more abundant since the establishment of the first sleep disorders clinic in 1970 (Spriggs, 2015). The formal accrediting organizations for programs concerning polysomnography within the United States include the Commission on Accreditation of Allied Health Education Programs (CAAHEP) and the Commission on Accreditation for Respiratory Care (CoARC). While the CAAHEP provides accreditation for various curricula related to the Allied Health disciplines, CoARC is the primary accrediting body for respiratory care and its multiple add-on specializations, such as sleep disorders specialists (SDS). These two accrediting commissions ensure that all sleep education programs within the United States maintain a minimum degree of standards. As such, these commissions set the core curricula of sleep programs to promote consistency in education.

Students qualify for board examinations through the BRPT if they have completed one of the following curricula: a CoARC respiratory therapy advanced level program with PSG add-on, an electro neurodiagnostic technologist program with PSG add-on, or a Committee on Accreditation for Polysomnographic Technologist Education (CoA PSG via CAAHEP) stand-alone program (BRPT, n.d.). The AAST endorses the completion of one of these accredited sleep education programs that are currently offered at four-year universities and two-year technical institutions or community colleges (BRPT, n.d.). In total, there are five CoARC-accredited advanced level sleep programs, twelve electro-neurodiagnostic technologist programs, and 37 CoA PSG stand-alone

programs within the United States alone. The curriculum, requirements, and student expectations of each differ to some degree.

PAP Adherence Education Techniques

With key causes of PAP non-adherence being identified, the techniques that are implemented to overcome those causes can be developed and implemented. One such intervention that has revealed positive results is that of support and troubleshooting phone calls taking place after a patient's initial titration study to improve PAP understanding. Mehrtash et al. (2019) found that this form of telephone-linked communication has been shown to increase the median PAP use by 0.9 hours/night after six months and 2.0 hours/night after 12 months. In performing the standard PAP titration protocol, the patient often only has one night to ask the sleep technologist questions regarding the therapy, such as why they need to wear it, the implications of wearing the mask interface nightly, travel concerns, equipment malfunctions, etc. The CPAP-SAVER intervention was designed to promote optimal adherence through these phone calls and primarily took place during the first week of PAP therapy use. The study described the CPAP-SAVER intervention as a cost-effective method that exhibited positive effects on initial beliefs and attitudes of patients regarding their PAP therapy, which have both been correlated with long-term adherence to therapy (Shapiro, 2021).

To expand upon what the CPAP-SAVER intervention aimed to accomplish, telemedicine interventions have been utilized with success, especially throughout the pandemic lockdowns induced by SARS-CoV-2. Telemedicine videoconferencing has been implemented to perform follow-up consultations with patients following their initial and continued uses of PAP therapy. Novel PAP machines also retain data storage,

download, and upload capabilities over Wi-Fi. This has allowed objective information regarding the patient's control of their OSA, such as apnea-hypopnea index, air leaks, usage time, etc., to be digitally sent to their respective sleep medicine provider. In fact, one study concluded that telemonitoring techniques via data downloads enhanced and reinforced 90-day PAP adherence rates, although this significant effect was not observed in telemedicine-based education techniques, such as videoconferencing (Mehrtash et al., 2019). However, patient education at multiple points-of-contact should remain paramount in the continued effort to improve overall PAP adherence rates. Patients' lack of understanding regarding the impact of untreated OSA, health benefits of compliant therapy, and proper use of PAP therapy with mask interface applied are crucial factors in suboptimal adherence (Olsen et al., 2008)

Despite these telecommunication efforts, unidirectional reinforcement, such as sleep medicine provider to patient, alone has not been adequate to improve adherence (Mehrtash et al., 2019). Group support has been conducted in the past to improve patient outcomes in other disease processes, and this intervention has shown equal promise with regards to OSA. For instance, A.W.A.K.E.™ (Alert, Well, and Keeping Energetic) is a nationwide education-oriented organization that maintains support groups for those suffering from various sleeping disorders within each U.S. state.

One ad hoc assessment of adherence improvement compared a control group receiving individual education with the cohort receiving group education. The results of the assessment expressed an improvement in the percentage of nights PAP therapy was used from 62.1% ± 37.0% to 67.2% ± 30.8% ($p = .02$) and a decrease in the percentage of patients that discontinued therapy from 14.5% to 10.6% ($p < .001$) in the individual and

group education groups, respectively (Olsen et al., 2008). As such, these findings reflect the importance that group support maintains with both patient education and adherence to therapy. It can be assumed that this intervention reduces the social stigma that surrounds PAP therapy, as patients are subjected to others receiving the same therapy. They can share with those who have similar concerns or questions as they do and may otherwise have been too nervous to ask in an individual session.

Moreover, the level of training of a sleep disorder technician is an essential factor for the sleep centers. A sleep disorder therapist requires an associate degree or certificate in polysomnography to then gain credentials in the field of sleep medicine. It is also possible to train in a different specialty and then cross-train in the field of polysomnography. Individuals with the proper qualification and certification can detect the presence of the sleep disorder in patients and guide the patients post-care according to the symptoms depicted in the patients. The level of training for the therapist affects the functionality of the sleep centers due to the service to their patients.

The technicians thus must get a certification that permits them to provide services that relate to sleep disorders. The BRPT identifies the qualified levels of personnel (Lins-Filho et al., 2020). The sleep centers depend on qualified personnel to help their patients through the provision of adequate patient education. Patient education and the level of training of the therapists are significant contributing factors to the sleep centers (Lins-Filho et al., 2020). Those two factors directly influence both the correct diagnosis and the patients' cooperation to control the sleep disorders and accompanying co-morbidities (Lins-Filho et al., 2020).

The PAP-NAP, or resting period, is a tool to enhance PAP therapy adherence. The PAP-NAP is when a patient comes into the lab during the day and works one-on-one with a sleep specialist to improve adherence outcomes. The goal of this tool is not to sleep, but to work through any barriers while on the PAP device to see if continued efforts towards adherence are viable. Barriers could include claustrophobia, general anxiety surrounding the PAP device, and pressure intolerance.

The PAP-NAP is based on current procedural terminology codes and combines psychological and physiological treatments into one procedure, which increases contact time between sleep dynamic therapy (SDB) patients and polysomnography technologists to enhance PAP therapy adherence (CPT: Physicians' Current Procedural Terminology 2018, 2018). AP includes mask and pressure desensitization, emotion-focused therapy to overcome aversive emotional reactions, mental imagery to divert patient attention from mask or pressure sensations, and physiological exposure to PAP therapy during a 100-minute nap period (Haynes, 2005).

Krakow et al. (2008) conducted a one-of-a-kind study that showed improved PAP adherence when a PAP- NAP was implemented. All 99 insomnia patients were diagnosed with sleep disorder breathing (mean AHI 26.5 ± 26.3, mean RDI 49.0 ± 24.9), and all reported a history of psychiatric disorders or symptoms, as well as a resistance to PAP therapy. Among thirty-nine patients completing the PAP-NAP:

- Ninety percent completed overnight titrations, compared with 63% in the historical control group.
- Eighty-five percent of the nap-tested group filled PAP therapy prescriptions for home use compared with 35% of controls; and

- Sixty-seven percent of the nap-tested group maintained regular use of PAP therapy compared with 23% of the control group. (Krakow et al., 2008)

Using standards from the field of sleep medicine, the nap-tested group demonstrated objective adherence of 49% to 56% compared to 12% to 17% among controls (Krakow et al., 2008). All studies were reimbursed using CPT 95807–52. In this pilot study, the PAP-NAP functioned as a brief, useful, and reimbursable procedure to encourage adherence in insomnia patients with SDB in comparison to a historical control group that did not undergo the procedure.

Behavioral Therapy Interventions

Behavioral therapy interventions have been implemented with varying degrees of success to improve PAP adherence. These modalities have included cognitive behavioral therapy (CBT), motivational enhancement therapy (MET), and a peer-buddy system (PBS). The efficacy of CBT has not been consistent within the research. A pilot randomized placebo-controlled trial expressed no differences in short-term CPAP use between the intervention and control groups, whereas another study found a greater acceptance to PAP therapy in the intervention group when compared to the control group (Mehrtash et al., 2019). In contrast, MET, an approach to encourage a patient's internal motivation to acclimate to PAP therapy, was shown to improve average nightly adherence by 99.0 minutes/night at a six-month interval in one randomized controlled trial (Bakker et al., 2016). In another randomized controlled study, PBS, which pairs a newly diagnosed OSA patient with a peer that retains former experience with PAP therapy, was shown to increase weekly adherence in the intervention group ($p = .04$) with patient satisfaction positively correlated to improved adherence ($p = .02$) (Parthasarathy

et al., 2013). Therefore, while variations of behavioral therapy demonstrate promising results in improved PAP adherence, others, such as CBT, require further research to quantify their overall effect.

Health Literacy Today

According to *Healthy People,* "Health literacy is the degree to which individuals can obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Peterson, 2011) he CDC emphasizes health literacy as necessary to everyone since, at some point in life, people would need to understand and utilize health services and information (CDC, 2021). Health literacy is not only useful when people are sick, but always, because everyday life comprises of taking care of one's health (CDC, n.d.; Muhanga & Malungo, 2017). Health literacy should not be mistaken with literacy because even those who can read and write and are good with using numbers can face issues of health literacy. When people are not accustomed with how their bodies work, they cannot evaluate risks that affect their safety and health. They may be scared and confused regarding serious illnesses, and they may rely on hearsay to vote on public health issues affecting their community's health. Health conditions that need complicated self-care, for example, patients with severe OSA who use PAP devices, can prove challenging to use and uphold adherence to treatment requirements. Therefore, it is imperative to know how to maintain a healthy lifestyle choice and prevent one's body from diseases all together.

The Epworth Sleepiness Scale (ESS) instrument used in the study is a self-reported measure of a patient's sleepiness, therefore responses are limited to what individuals are willing to share. The ESS is also in English, so participants with a poorer

understanding of the language my not have understood the questions properly. The reliability and validity of the Spanish translation of the instruments was not available.

In a European health literacy survey from 2009-2012 regarding health literacy crises, the World Health Organization's (WHO) research team found that half of adults have inadequate health literacy skills, and this adversely affects their health (Kickbusch & de Ruijter, 2021). According to the survey, it was revealed that 35% of the respondents had problematic health literacy, and 12% of respondents had inadequate basic health literacy. Repercussions of a lack of health literacy competencies include making less healthy choices, poorer health, less self-management, risky behavior, and more hospitalization. In turn, it denies the society productive personnel and financial resources. There needs to be a policy-based action to ensure that the public is acquainted with necessary health literacy.

According to Peterson (2011), the scope of health literacy should incorporate the health system, including people who:

- create policy
- promote healthcare
- develop health materials
- practitioners
- regulatory agencies
- home health care
- public health agencies
- insurers
- accreditation groups (Peterson, 2011)

Comprehension of health literacy guides the health system towards adopting policies that would resolve the discord between a person's needs and the demands of the health systems (Peterson, 2011). Lack of health literacy is detrimental to health and can cause death, primarily where devices used to manage health issues are involved. For instance, in OSA conditions, there is a need for sleep health literacy. Williams et al. (2016) conducted a study based on a tailored approach to sleep health literacy using the web, and it was found that computer access and use of the internet affect health habits among the New York minority. Therefore, web-based information would be an effective means to increase the literacy about OSA and could improve the use of sleep-related services among the minority group. The same study referred to a previous survey that noted a disparity in adherence to PAP treatment between the African American and Caucasian participants with the Caucasians utilizing the PAP devices more than their African American counterparts. While there are no clear explanations for these disparities, studies have suggested obesity and genetic factors, as well as sleep duration and socioeconomic status to be impactful (Williams et al., 2016). Novel adherence strategies to avoid the underutilization of CPAP devices should promote quality of life and reduce costs. This could be achieved by ensuring good health literacy among people and the general health system. Efficient management and treatment of OSA are effective in reducing risk factors such as hypertension, diabetes, daytime sleepiness, and cognitive impairment, which consequentially burden society.

Summary

Chapter Two disseminated a literature review of the development and financial burden to the U.S. healthcare system with non-adherence to treatments in healthcare,

which has been associated with many factors established from various literature, journals, and studies. Included was a discussion of the financial fallout that OSA conditions have on the present healthcare system. Additionally, Chapter Two discussed the importance of PAP adherence on an individual's ability to attain care and management of OSA.

Chapter 3

Methodology

Numerous studies have evaluated the benefits of various interventions to improve PAP acceptance and adherence (Mehrtash et al., 2019). Such interventions include intensified education and follow-up programs; however, few studies have evaluated interventions related to the impact that a sleep technologist's or discharge planner's credential level has on OSA patients' PAP adherence. Current investigations have been performed to ascertain the causation for PAP adherence for a multitude of patient populations and disciplines of care. The gap may lay in the few studies that have been performed pertaining to non-adherence in the OSA patient populations due to the type of disease-specific education provided. There also seems to be a gap in the investigation of moderators such as age, gender, ethnicity, financial status, or geographical location and their impact on PAP adherence.

The significance of instructing PAP adherence training within sleep education programs is epitomized by the sheer economic and societal impact that untreated OSA retains on the population. Patients with known OSA require effective treatment, and as PAP therapy is still considered the first-line gold standard modality for doing so, it is the responsibility of the sleep medicine community to ensure PAP adherence rates improve. To fulfill this responsibility, PAP adherence training must be implemented as a standard component of the core curricula of all sleep education programs within the United States. Once graduates are made fully aware of their function in promoting adherence, they will be more apt to identify and resolve issues that may induce PAP non-adherence in the patients that they serve.

Not only does untreated OSA have the capacity to induce a multitude of comorbid conditions, but the condition also has a lasting fiscal impact on the U.S. economy and healthcare system if left untreated. This research aims to explore PAP adherence, contributing factors, and PAP education. PAP adherence is especially important for today's healthcare worker in the field of sleep medicine. It is imperative that today's higher education programs in medicine, physical therapy, respiratory therapy, nursing, and others, include medical compliance in their curriculum. According to (Weaver, 2019) it is estimated that 29 to 83 percent of patients are noncompliant or nonadherent, when noncompliance and/or nonadherence is defined as a mean of $\geq$ 4 hours of PAP use per night. To ensure the delivery and safety of quality healthcare, a need exists to determine if poor PAP compliance stems from a lack of patient education and the therapist's level of training at sleep centers. Additionally, there is a need to identify contributing factors of non-adherence. Moderator variables are also investigated for a defined causal relationship, as well as the strength of the relationship between mediators that may lead to the reasoning behind the moderator relationship (Baron & Kenny, 1986).

Research Method

The research method for this study involves a research design through a retrospective data review, commonly referred to as a retrospective chart review (RCR) or medical record review (MRR) of existing patient records. This method uses the electronic medical records for retrieval of pertinent medical data for available OSA patient cohort data ascertaining a correlation between the adherence or refusal of PAP therapy- and disease-specific OSA educational support provided. Retrospective chart reviews are a popular methodological research method used in multiple healthcare disciplines,

including residency training programs, quality control and assessment, healthcare educational programs, epidemiological studies, inpatient and outpatient studies, and other types of clinical research. One quarter of medical research is conducted through retrospective chart reviews (Vassar & Holzmann, 2013).

Advantages of a Retrospective Chart Review

There are several advantages to this type of research method, including ease of attaining existing pertinent patient data, efficiency, and dissemination for medical concerns, such as the case of medical time constraints for needed treatments. Carefully chosen cohorts can give a direct representation of incidence of diseases and health conditions, rather than relying on an odds ratio. RCR allows a study to be designed for multiple outcome evaluations to be performed at the same time based on chosen variables (Vassar & Holzmann, 2013).

Disadvantages of a Retrospective Chart Review

Disadvantages of RCR studies include infrequent outcomes that may require a larger population for the study, which in turn cause delays in the outcomes, as the study would need to be performed over a longer period. Other disadvantages are the increasing utilization costs for staff, including time, as well as incidents of disease that may be present at the forefront of the study. These diseases can be misdiagnosed, causing a skew in the available data (Vassar & Holzmann, 2013).

Rationale for the Retrospective Chart Review

Due to the availability and wealth of pertinent patient data pertaining to this research topic, a retrospective chart review was selected as the research method for this study. It was conducted on a smaller scale to able to be completed quicker and with little expense.

The intent was to disseminate available OSA patient cohort data ascertaining a correlation between the adherence or refusal of PAP therapy- and disease-specific OSA educational support provided.

For continuity of research and avoidance of commonly reported RCR mistakes, a literature review was conducted and reviewed that included a summary of evaluations to prevent common mistakes within the RCR research model.

Ethical Considerations

This RCR investigation followed all policies and procedures as designated by the Youngstown State University Institutional Review Board (IRB) to ensure that all research was conducted in an ethical manner(Appendix C). All attempts were made to protect any patient identifiers, including name, patient medical record number, and an exposure limit of the sensitive patient data to those individuals who were listed on the IRB. This process was to eliminate, or minimize, potential risks to personal health or identity information to participants or any inadvertent Health Insurance Portability and Accountability Act (HIPAA) violations as set for by the Department of Health and Human Services (HHS)

Inclusion Criteria

A randomized selection process was instituted, as subjects were retrospectively pooled from an existing EMR database. The primary inclusion criterion was a known diagnosis of obstructive sleep apnea as defined by the International Classification of Diseases (ICD-10-CM). A secondary inclusion criterion was established to reflect the intent of this research and involved the continued use or prior attempt of some variation of PAP therapy. Subjects who retained consistent PAP use, as outlined by the Centers for Medicare and Medicaid Services (CMS) standard, were designated compliant. Those who

retained a history of prior use were deemed non-compliant. Adherence is defined by CMS, as using PAP for four or more hours per night for at least 70% of nights during a consecutive 30-day period anytime during the first three months of initial usage (Center for Medicare and Medicaid Services, n.d.).

Exclusion Criteria

Participants were excluded from this study with a negative polysomnogram resulting from a diagnostic AHI of < 5.0. Exclusion also occurred if the prospective participant was diagnosed with obstructive sleep apnea, but had yet to receive their initial titration study, home PAP equipment, and follow-up consultation. A sample size of n = 139 was utilized in the study, with a sample size of N = 417 prior to randomization.

Participants

Participants were selected randomly and systematically with every third subject in the database being selected from a pool of established patients within an internal, secure EMR database. Participant selection was performed with the intent to evaluate how different physical, cognitive, and socioeconomic factors may influence PAP compliance within a diverse population of patients. Participants, 18-84 years of age and of Caucasian, Hispanic or Latino, and African American background, were included with a predominant ICD-10-CM diagnostic code of OSA. However, other prevalent ICD-10-CM diagnostic codes related to sleep medicine included excessive daytime sleepiness, narcolepsy, and REM behavior disorder. Participants presenting with these secondary conditions were only integrated into the study if they retained a concomitant diagnosis of obstructive sleep apnea.

Research Procedure

The research procedure was initiated with a capture of information from MEDITECH EHR software, of which prospective participants were pooled in correspondence with the established inclusion criteria. The database search was constrained to patients of the sleep disorders clinic – particularly the sleep consultation department of the clinic. Participants identified for inclusion (n = 139), (N=417) based on established parameters were separated in two cohort groups during the initial process of data collection: compliant or non-compliant. This was determined via the CMS standard of ≥ 4 hours of nightly PAP therapy use for 70% of nights. PAP compliancy download reports were implemented to direct placement of the randomly selected subjects into one these predefined groups.

Subsequent information in relation to the research inquiry was gathered from the same database. In addition to, the following research elements were included to assess their impact on PAP compliance: age, ethnicity, race, gender, health insurance, treatment type, degree of PAP compliance, credential level of the sleep practitioner that performed the most recent PAP titration study, if the sleep medicine consultation visit was conducted by either a DO or certified nurse practitioner, the number of rescheduled or rebooked appointments made, any evidence of a prior failure of acclimating to PAP therapy, and the calculated Charlson Comorbidity Index. All collected information was then transcribed into a spreadsheet for documentation purposes.

Data Analysis

The following research questions were instrumental in guiding the analysis of the collected data:

1. Do variables, such as age, gender, ethnicity, or type of healthcare coverage, have an impact on PAP adherence?
2. Does the Charlson Comorbidity Index predict patient PAP adherence?
3. Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?
4. Does prior PAP failure predict current PAP adherence?

Data was compiled, and analyses were completed using Intellectus (2022) statistical analysis software. To address all stated research questions in this analysis, both descriptive and inferential statistics were used. Reliability estimates were calculated where appropriate. Binary logistic regression analysis was used to evaluate existing relationships. Logistic regression was conducted to determine the relationship of certain factors on the likelihood that participants would be PAP-adherent. With the dependent variable being categorical and dichotomous, and a mixture of continuous and categorical independent variables, logistic regression was the appropriate statistical test to predict association (Newby, 2010). Logistic regression calculates the probability of success over the probability of failure (Newby, 2010).

Demographic moderator variables of age, gender, ethnicity, and level of insurance were collected and analyzed by means from an existing, secure EMR database without any preceding knowledge of a pooled cohort's age, gender, racial/ethnic background, degree of PAP compliance, or obstructive sleep apnea severity. The primary inclusion criterion was a known diagnosis of obstructive sleep apnea as defined by the International Classification of Diseases (ICD-9/10-CM). A secondary inclusion criterion was established to reflect the intent of this research and involved the continued use, or prior

attempt, of some variation of PAP therapy. Subjects who retained consistent PAP use, as outlined by the Centers for Medicare and Medicaid Services (CMS) standard, were designated compliant. Those who retained a history of prior use were deemed non-compliant. This information was crucial in the development of the overview and representation of participant populations within this study.

A binary logistic regression was conducted to examine whether age, race, gender, and insurance level had a significant effect on the odds of observing the one-category of PAP Compliance. The assumption of absence of multicollinearity was examined in all logistical regressions ran. Three outliers were identified yet were kept in the study due to being legitimate observations. The outliers identified were participants who had extremely high BMI and AHI values. As mentioned earlier**,** these variables are legitimate and contribute to the research.

Variance inflation factors (VIFs) were calculated to detect the presence of multicollinearity between predictors. High VIFs indicate increased effects of multicollinearity in the model. VIFs greater than five are cause for concern, whereas VIFs of ten should be considered the maximum upper limit (Menard, 2009). McFadden's R-squared was calculated to examine the model fit, where values greater than .2 are indicative of models with excellent fit (Louviere et al., 2000).

Summary

Chapter 3 identified the research methodology to disseminate available OSA patient cohort data ascertaining a correlation between the adherence or refusal of PAP therapy- and disease-specific OSA educational support provided. A retrospective chart review method of research was chosen for this study due to the availability and wealth of

pertinent patient data pertaining to this research topic. Subsequent information in relation to the research inquiry was gathered from the same database. The following research elements were included to assess their impact on PAP adherence: age, ethnicity, race, gender, health insurance, treatment type, degree of PAP compliance, credential level of the sleep practitioner that performed the most recent PAP titration study, any evidence of a prior failure of acclimating to PAP therapy, and the calculated CCI. Chapter 4 reveals the results of the data analysis. Chapter 5 discusses the current literature and summary of the study, the findings, limitations, and implications. Additionally, recommendations for future research are detailed in Chapter 5.

Chapter Four

Results

Numerous studies have evaluated the benefits of various interventions to improve PAP acceptance and adherence (Boon et al., 2018; Ratneswaran et al., 2021; Sturm et al., 2019). Such interventions include intensified education and follow-up programs; however, few studies have evaluated interventions related to what impact the credential level of the sleep technologist or discharge planner have on OSA patients' PAP adherence. Additionally, few studies have examined how the Charlson Comorbidity Index (CCI) plays a role in PAP adherence. Current investigations have been performed to ascertain the causation for PAP adherence for a multitude of patient populations and disciplines of care. Another gap may lay in the few studies that have been performed pertaining to non-adherence in the OSA patient populations due to the type of disease-specific education provided. There is also a gap in the investigation of moderators such as age, gender, ethnicity, type of healthcare coverage, or geographical location, and the role they may play in the lack of PAP adherence. This study investigated contributing factors with PAP non-adherence.

The following research questions were instrumental in guiding the analysis of the collected data:

1. Do variables, such as age, gender, ethnicity, or type of healthcare coverage, have an impact on PAP adherence?
2. Does the Charlson Comorbidity Index predict patient PAP adherence?
3. Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?

4. Does prior PAP failure predict current PAP adherence?

This chapter will disseminate the specific data collected to ascertain if demographic moderator variables, the CCI, credential level of the sleep technologist or discharge planner, and prior PAP failure influence PAP adherence. Additionally, the specific research questions will be addressed individually within this chapter by utilizing appropriate regression analysis software.

Demographics

The demographic moderator variables of age, gender, ethnicity, healthcare coverage, and geographic zone were collected and analyzed. This information was collected from an existing, secure EMR database without any preceding knowledge of a pooled cohort's age, gender, racial/ethnic background, degree of PAP compliance, or obstructive sleep apnea severity.

Participants were selected randomly from a pool of established patients within an internal, secure EMR database. Participant selection was performed with the intent to evaluate how different physical and socioeconomic factors may influence PAP compliance within a diverse population of patients. Participants who were 18-84 years of age and of Caucasian, Hispanic or Latino, and African American ethnicities were included with a predominant ICD-9/10-CM diagnostic code of obstructive sleep apnea. However, other prevalent ICD-9/10-CM diagnostic codes related to sleep medicine included excessive daytime sleepiness, narcolepsy, and REM behavior disorder. Participants presenting with these secondary conditions were only integrated into the study if they retained a concomitant diagnosis of obstructive sleep apnea. Participants within the study yielded a sample size of $n = 139$. Summary statistics were calculated for

each interval and ratio variable. Frequencies and percentages were calculated for each nominal variable.

Descriptive Statistics

Frequencies and Percentages

The predominant sex was male (n = 78, 56.12%). The most frequently observed category of ethnicity as Caucasian (n = 123, 88.49%). Most participants in this sample were employed (n = 70, 50.36%). Frequencies and percentages of subject characteristics are presented in Table 1.

Table 1

Subject Characteristics - Frequency Table for Nominal Variables

Variable	*n*	*%*
Gender		
Female	61	43.88
Male	78	56.12
Race		
Caucasian	123	88.49
African American	12	8.63
Declined	3	2.16
Unable	1	0.72
Missing	0	0.00
Employment		
Employed	70	50.36
Not Employed	18	12.95
Retired	40	28.78
Retired/Disabled	4	2.88
Not Employed/Disabled	6	4.32
Student	1	0.72
Missing	0	0.00
Prior PAP Failure	39	28.1

Note. Due to rounding errors, percentages may not equal 100%.

Summary Statistics Table for Interval and Ratio Variables

Most subjects were adults, whose mean age was 59.29 years old. Summary statistics were calculated for BMI, AHI on the diagnostic study, as well as AHI on PAP therapy. The average BMI for the study cohort was 37.19 The average for AHI on the diagnostic study observed for the cohort study was 30.54 (SD = 26.04, SE_M = 2.21, Min = 5.00, Max = 119.00, Skewness = 1.35, Kurtosis = 1.00). The average for AHI on PAP therapy for the study cohort was 3.53 (SD = 5.56, SE_M = 0.48, Min = 0.00, Max = 52.10, Skewness = 5.92, Kurtosis = 44.57). When the skewness is greater than two in absolute value, the variable is asymmetrical about its mean. When the kurtosis is greater than or equal to three, then the variable's distribution is markedly different than a normal distribution in its tendency to produce outliers (Westfall & Henning, 2013). The summary statistics can be found in Table 2.

Table 2

Summary Statistics Table for Interval and Ratio Variables

Variable	*M*	*SD*	*n*	SE_M	Min	Max	Skewness	Kurtosis
Age	59.29	13.15	139	1.12	16.00	84.00	-0.45	0.17
BMI	37.19	8.77	139	0.74	17.90	61.40	0.64	0.09
AHI on Diagnostic	30.54	26.04	139	2.21	5.00	119.00	1.35	1.00
AHI on PAP Therapy	3.53	5.56	137	0.48	0.00	52.10	5.92	44.57

Frequencies and percentages were calculated for PAP Adherence. The most frequently observed category of PAP Adherence was nonadherence (n = 75, 53.96%). Frequencies and percentages are presented in Table 3.

Table 3

Frequency Table for PAP Adherence

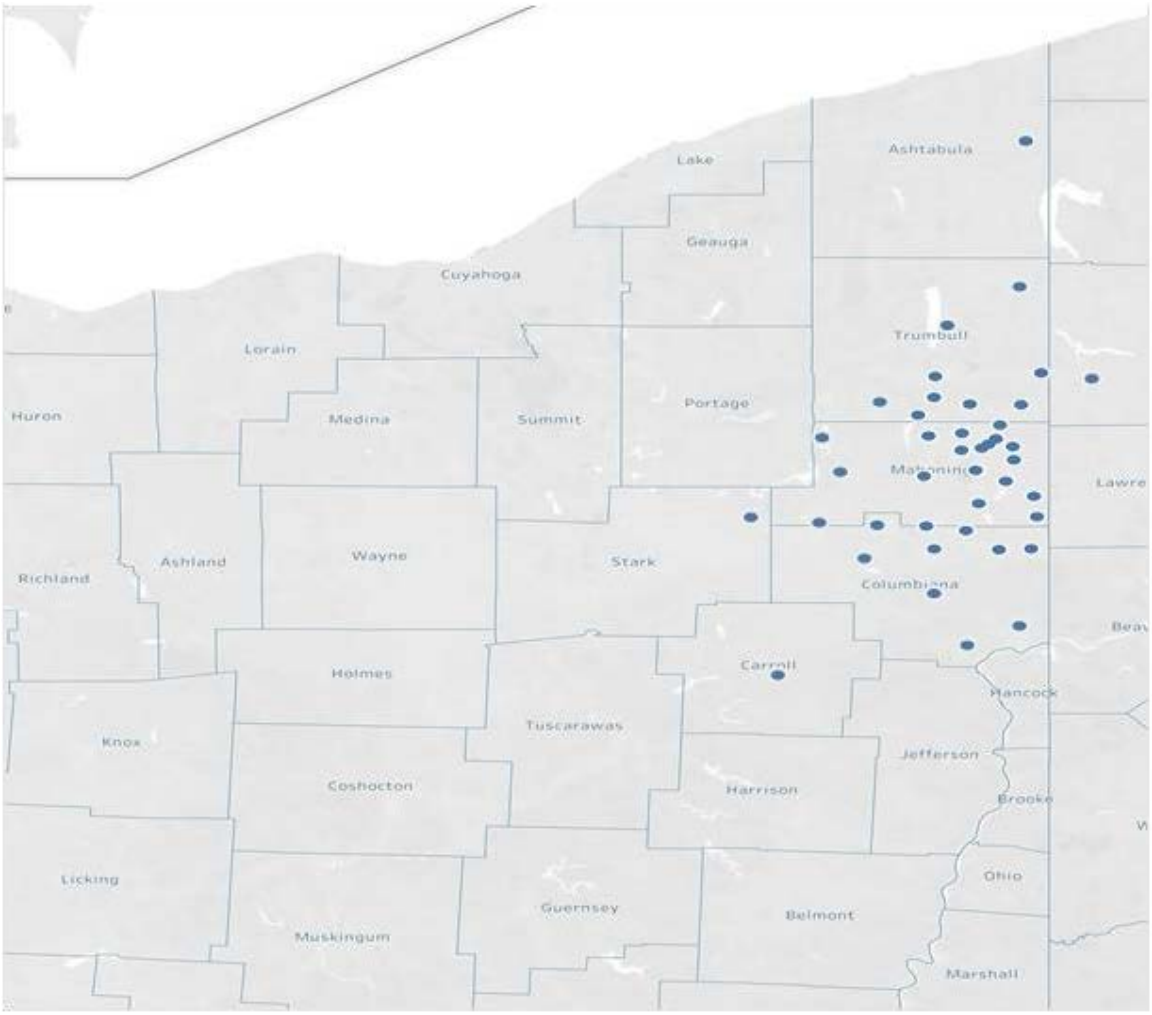
Variable	*n*	*%*
PAP Adherence		
Adherent	64	46.04
Non-adherent	75	53.96

Note. Due to rounding errors, percentages may not equal 100%.

The results are also presented for the sample, per zip code in a geospatial data map. This was conducted so that the data could be analyzed more specifically in the area where most of the data was generated. The results for this can be found in Figure 1.

Figure 1

Zip Code Analysis of Patient Population



Research Question Specific Analyses

Basic assumptions that must be met for logistic regression include independence of errors, linearity in the logit for continuous variables, absence of multicollinearity, and lack of strongly influential outliers (Westfall & Henning, 2013). The following assumptions of binary logistic regressions were addressed:

1. Binary dependent variable: Described analyses reported as a binary outcome variable.

2. Logistic regression requires each observation to be independent: The easiest way to check this assumption is to create a plot of residuals against time (i.e., the order of the observations) and observe whether there is a random pattern. If there is *not* a random pattern, then this assumption may be violated.
3. Good fit: Hosmer-Lemeshow goodness of fit.
4. No collinearity with other independent variables: The most common way to detect multicollinearity is by using the variance inflation factor (VIF), which measures the correlation and strength of correlation between the predictor variables in a regression model.
5. Outliers: The most common way to assess for extreme outliers and influential observations in a dataset is to calculate Cooks Distance for each observation. Mahalanobis distance was used with the same observation.
6. Assumes linearity of independent variables and log odd use the Box-Tidwell Test (Westfall & Henning, 2013).
7. Sufficient sample size to test: As a rule of thumb, researchers should have a minimum of ten cases with the least frequent outcome for each explanatory variable. For example, if there are three explanatory variables, and the expected probability of the least frequent outcome is 0.20, then the sample size should be at least (10*3) / 0.20 = 150.

Research Question #1

Do demographic variables, such as age, gender, ethnicity, or type of healthcare coverage, have an impact on PAP adherence?

A binary logistic regression was conducted to examine whether age, race, gender, and insurance level had a significant effect on the odds of observing the one-category of PAP compliance. The reference category for PAP compliance was zero. Insurance was broken down into two categories of public and private. The assumption of absence of multicollinearity was examined.

Variance inflation factors (VIFs) were calculated to detect the presence of multicollinearity between predictors. High VIFs indicate increased effects of multicollinearity in the model. All predictors in the regression model have VIFs less than 10. Table 4 presents the VIF for each predictor in the model.

Table 4

Variance Inflation Factors for Age, Race, Gender, and Insurances

Variable	VIF
Age	1.03
Race	2.17
Gender	1.11
Insurances	1.03

Results

The overall model was not significant, $\chi^2(7) = 13.45$, $p = .062$, suggesting that age, race, gender, and insurances did not have a significant effect on the odds of observing the one-category of PAP compliance. McFadden's R^2 was calculated to examine the model fit, where values greater than .2 are indicative of models with excellent fit (Louviere et al., 2000). The McFadden R^2 value calculated for this model was 0.07. Since the overall model was not significant, the individual predictors were not examined further. Table 5 summarizes the results of the regression model.

Table 5

Logistic Regression Results with Age, Race, Gender, and Insurances Predicting PAP Compliance

Variable	*B*	*SE*	χ^2	*p*	*OR*	95.00% CI
(Intercept)	-1.40	0.88	2.51	.113	-	-
Age	0.02	0.01	1.72	.189	1.02	[0.99, 1.05]
Race Hispanic/Latino	16.84	2,399.54	0.00	.994	2.06×10^7	[0.00, Inf]
Race African American	-0.62	0.68	0.84	.361	0.54	[0.14, 2.03]
Race Declined	16.41	1,383.02	0.00	.991	1.34×10^7	[0.00, Inf]
Gender	0.52	0.38	1.95	.163	1.69	[0.81, 3.53]
Insurances	0.47	0.37	1.63	.202	1.60	[0.78, 3.32]

Note. $\chi^2(7) = 13.45$, $p = .062$, McFadden $R^2 = 0.07$.

Research Question #2

Does the Charlson Comorbidity Index predict patient PAP adherence?

A binary logistic regression was conducted to examine whether CCI had a significant effect on the odds of observing the one-category of PAP compliance. The reference category for PAP compliance was zero.

Results

The overall model was not significant based on an alpha of .05, $\chi^2(1) = 0.97$, $p = .325$. This suggests that CCI did not have a significant effect on the odds of observing the one-category of PAP compliance. McFadden's R^2 was calculated to examine the model fit, where values greater than 0.2 are indicative of models with excellent fit (Louviere et al., 2000). The McFadden R^2 value calculated for this model was 0.01. Since the overall model was not significant, the individual predictors were not examined further. Table 6 summarizes the results of the regression model.

Table 6

Logistic Regression Results with Charlson Comorbidity Index Predicting PAP Compliance

Variable	*B*	*SE*	χ^2	*p*	*OR*	95.00% CI
(Intercept)	-0.08	0.29	0.07	.793	-	-
Charlson Comorbidity Index	0.08	0.08	0.95	.329	1.08	[0.93, 1.26]

Note. $\chi^2(1) = 0.97$, $p = .325$, McFadden $R^2 = 0.005$.

Research Question #3

Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?

A binary logistic regression was conducted to examine whether the credential level of the therapist or discharge planner had a significant effect on the odds of observing the one-category of PAP compliance. Credential level was broken down into the following categories of RRT/CRT with sleep credentials, non-RRT/CRT healthcare provider with sleep credentials, and healthcare employees with no sleep credentials.

Results

The overall model was not significant based on an alpha of .05, $\chi^2(2) = 0.29$, $p = .866$, suggesting that credential level of the therapist did not have a significant effect on the odds of observing the one-category of PAP Compliance. McFadden's R^2 was calculated to examine the model fit, where values greater than 0.2 are indicative of models with excellent fit (Louviere et al., 2000). The McFadden R^2 calculated for this model was 0.00. Since the overall model was not significant, the individual predictors were not examined further. Table 7 summarizes the results of the regression model.

Table 7

Logistic Regression Results with Credentialed Predicting PAP Compliance

Variable	*B*	*SE*	χ^2	*p*	*OR*	95.00% CI
RRT/CRT with Sleep Credentials	0.14	0.26	0.28	.600	-	-
Credentialed Healthcare Professionals with Sleep Credentials	-0.04	0.37	0.01	.922	0.96	[0.47, 1.99]
Credentialed Healthcare Employees with No Sleep Credentials	0.23	0.51	0.20	.651	1.26	[0.47, 3.40]

Research Question #4

Does prior PAP failure predict current PAP adherence?

A binary logistic regression was conducted to examine whether prior PAP failure had a significant effect on the odds of observing the one-category of PAP compliance. The reference category for PAP compliance was zero.

Results

The model was evaluated based on an alpha of .05. The overall model was significant, $\chi^2(1) = 17.93$, $p < .001$, suggesting that prior PAP failure had a significant effect on the odds of observing the one-category of PAP compliance. McFadden's R^2 was calculated to examine the model fit, where values greater than .2 are indicative of models with excellent fit (Louviere et al., 2000). The McFadden R^2 value calculated for this model was 0.09. The effect of the prior PAP failure was significant, $B = -1.68$, OR = 0.19, $p < .001$, indicating that prior PAP failure decreases the odds of observing PAP compliance. Table 8 summarizes the results of the regression model.

Table 8

Logistic Regression Results with Prior PAP Failure Predicting PAP Compliance.

Variable	*B*	*SE*	χ^2	*p*	*OR*	95.00% CI

(Intercept)	0.62	0.21	8.72	.003	-	-
Prior PAP Failure	-1.68	0.42	15.89	< .001	0.19	[0.08, 0.42]

Note. $\chi^2(1) = 17.93$, $p < .001$, McFadden $R^2 = 0.09$.

Summary

A retrospective chart review was completed to disseminate available OSA patient cohort data ascertaining an association between the adherence or refusal of PAP therapy- and disease-specific OSA educational support provided along with other moderator variables. A retrospective chart review method of research was chosen for this study due to the availability and wealth of pertinent patient data pertaining to this research topic. Subsequent information in relation to the research inquiry was gathered from the same database. The study includes $n = 139$ randomly selected participants with 56.1% being male and 43.9% female. The breakdown of the racial makeup of the participants was 8.6% African American, 88.5% Caucasian, 5.2% Hispanic/Latino, and 2.2% were listed as declined/other/unknown. Participants were selected randomly from a pool of established patients within an internal, secure EMR database. Participant selection was performed with the intent to evaluate how different physical, cognitive, and socioeconomic factors may influence PAP compliance within a diverse population of patients. Participants who were 18-84 years of age and of Caucasian, Hispanic or Latino, and African American background were included with a predominant ICD-9/10-CM diagnostic code of obstructive sleep apnea. The population was from Trumbull, Mahoning, Columbiana, Stark and Carroll counties. The following research elements were included to assess their impact on PAP adherence:

- age
- ethnicity

- gender
- health insurance
- treatment type
- degree of PAP compliance
- credential level of the sleep practitioner that performed the most recent PAP titration study
- any evidence of a prior failure of acclimating to PAP therapy
- calculated CCI

Results indicated age, race, gender, insurance, the credential level of healthcare provider, and CCI did not have a significant effect on the odds of observing PAP compliance. However, prior PAP failure was associated with predicting current PAP adherence. Moderator analysis also demonstrated that none of the potential moderators were associated with PAP adherence. A discussion of these results is presented in Chapter Five in addition to a summary of the study, the findings, limitations, and implications. Recommendations for future research are also detailed.

Chapter Five

Discussion and Conclusion

The intent of this investigation was to ascertain if contributing factors had an effect in positive airway pressure adherence in the OSA patient. Interventions to improve PAP adherence include intensified education and follow-up programs; however, few studies have evaluated interventions related to the impact that the credential level of the sleep technologist or discharge planner have on OSA patients' PAP adherence. Current investigations have been performed to ascertain the causation for PAP adherence for a multitude of patient populations and disciplines of care, but where the gap may lay is in the few studies that have been performed pertaining to non-adherence in the OSA patient populations due to type of disease-specific education provided (Weaver, 2019).

This chapter will discuss the data presented in Chapter Four. Specifically, it will examine findings from two viewpoints, statistical significance, and clinical relevance. It is important to understand that significance denotes concepts regarding the null hypothesis. However, there are statistically significant findings that may not have definite or important implications in PAP adherence. There are times when no statistical significance is found yet findings are suggestive of clinical relevance. This chapter will address the research questions identified.

The purpose of this study is a first step into understanding if any moderator variables had an association or influence on PAP adherence. Secondly, if there is any measurable association with the credential of the sleep technologist or discharge planner, CCI, or prior PAP failure that plays a role in influencing PAP adherence.

The following four research questions were instrumental in guiding the analysis of the

collected data:

1. Do variables, such as age, gender, ethnicity, or type of healthcare coverage have an impact on PAP adherence?
2. Does the Charlson Comorbidity Index predict patient PAP adherence?
3. Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?
4. Does prior PAP failure predict current PAP adherence?

Summary of the Results

This research study utilized a retrospective chart review (RCR) through the electronic medical record (EMR) database to investigate subjects' data related to the inclusion criteria outlined in this study. Data collection and subsequent analyses were accumulated by direct retrieval from the subjects' EMR database and the electronic health record (EHR), per establishment guidelines. Retrospective chart reviews are a popular methodological research method used frequently in multiple healthcare disciplines, including residency training programs, quality control and assessment, healthcare educational programs, epidemiological studies, inpatient and outpatient studies, and other types of clinical research. One quarter of medical research is through retrospective chart reviews (Vassar & Holzmann, 2013). Research questions were used to guide the analysis of the relationship between the variables.

There are several advantages to this type of research method, including: existing pertinent patient data are easily attained; it can be conducted efficiently and quickly; and it can be disseminated efficiently for medical concerns, such as the case of medical time constraints for needed treatments. Carefully chosen cohorts can give a direct

representation of incidence of diseases and health conditions, rather than relying on an odds' ratio. RCR allows a study to be designed to allow for multiple outcome evaluations to be performed at the same time based on variables chosen (Vassar & Holzmann, 2013).

The intent was to disseminate available OSA patient cohort data ascertaining a relationship between the adherence or prior PAP therapy failure. The ease of access to a recent, readily available database including patients with OSA was also a consideration for utilization of the RCR research design. For continuity of research and avoidance of commonly reported RCR mistakes, a literature review was conducted and reviewed that included a summary of evaluations to prevent common mistakes within the RCR research model.

A randomized selection process was instituted, as subjects were retrospectively pooled from an existing, secure EMR database without any preceding knowledge of a pooled cohort's age, gender, racial/ethnic background, degree of PAP compliance, or obstructive sleep apnea severity. Optimal PAP adherence is defined by the CMS as a mean of ≥ 4 hours of use for ≥ 70% of nights (Weaver, 2019).

Participants, 18-84 years of age and of Caucasian, Hispanic or Latino, and African American background, were included with a predominant ICD-9 and ICD-10 diagnostic code of obstructive sleep apnea. However, other prevalent ICD-9 and 10-CM diagnostic codes related to sleep medicine included excessive daytime sleepiness, narcolepsy, and REM behavior disorder. Participants presenting with these secondary conditions were only integrated into the study if they retained a concomitant diagnosis of obstructive sleep apnea.

The research procedure was initiated with a capture of information from

MEDITECH EHR Chicago, Illinois software, of which prospective participants were pooled in correspondence with the established inclusion criteria. The database search was solely constrained to patients of the sleep disorders clinic – particularly the sleep consultation department of this clinic. Participants identified for inclusion (n = 139) based on established parameters were then separated into two cohort groups during the initial process of data collection: compliant or non-compliant. This was determined via the CMS standard of ≥ 4 hours of nightly PAP therapy use for 70% of nights. PAP compliancy download reports were implemented to direct placement of the randomly selected subjects into one these predefined groups.

Subsequent information in relation to the research inquiry was gathered from the same database. The following research elements were included to assess their impact on PAP compliance: age, ethnicity, race, gender, ICD-9/10-CM coding, diagnosis, zip code, health insurance, degree of PAP compliance, credential level of the sleep practitioner that performed the most recent PAP titration study, any evidence of a prior failure of acclimating to PAP therapy, and the calculated CI.

Research Question #1

Do variables, such as age, gender, ethnicity, type of healthcare coverage, or geographic location with zip codes have an association to PAP adherence?

As previously discussed, this research investigation was an attempt to ascertain if patient demographics and disease severity drive PAP adherence. Research has revealed that these factors only explain a small amount of variance in adherence. Age and gender do not appear to influence CPAP adherence or there is only a weak relationship, which is often not clinically relevant (Weaver, 2019). None of the variable explored were found to

be statistically significant. A binary logistic regression was conducted to examine whether age, race, gender, and insurance level had a significant effect on the odds of observing the category of PAP compliance. This analysis revealed that no significant association existed between the variables of age, race, gender, and insurance level. The findings of this analysis of data are consistent with extant literature. Patel et al. (2021) conducted a study that reviewed 789,260 patients PAP adherence data via telemonitoring. Overall adherence determined by the CMS Medicare and Medicaid criteria was found to be 72.6%, yet varied dramatically by age and sex (Patel, 2021).

Research Question #2

Does the Charlson Comorbidity Index predict patient PAP adherence?

The Charlson Comorbidity Index (CCI) showed no statistical significance in predicting patient adherence to PAP. It is evident that CCI has a positive predictive capacity on PAP adherence because the beta coefficient of the CCI is positive (0.08), but the associated *p* value (*p* value >0.05) of the model suggests the predictive strength of the tool is statistically insignificant. The odds ratio and the probability of predicting PAP adherence is similarly very weak (1.08 times or 8%) and close to the reference category of zero. In other words, CCI predictive power for patient PAP adherence is 8% higher. The model indicates a 95% confidence that CCI has on average 7 to 26% more odds for predicting patient PAP adherence compared to the reference category. The finding implies that CCI is not a reliable tool for predicting the impact of OSA severity on patients' PAP adherence. The clinimetric properties of CCI have been investigated and found to be ideal for predicting long term mortality. Charlson et al. (2022), for example, noted that the tool has a higher level of predictive and incremental reliability, inter-rater

reliability, sensitivity, and concurrent validity. These impressive characteristics make CCI to be at par in terms of performance (concordant predictions) with other tools including Elixhauser, Kaplan-Feinstein, and the American Society of Anesthesiologists (ASA) classification. CCI, nonetheless, noted to be less effective in predicting the physical aspect of health-related quality of life when applied to OSA patients (Agrafiotis et al., 2022). These findings tally with the results of the study which indicates that the tool is highly reliable but performs dismally in predicting patients' adherence to PAP.

Studies conducted elsewhere observe a strong linkage between the prevalence rate of PAP adherence and severity of OSA (Jacobsen et al., 2017; Baratta et al., 2018). In Somers (2011), Wallace and Wohlgemuth (2014), Balakrishnan (2016), and Kusk (2022), severe Apnea Hypopnea Index (AHI) was associated with increased patients' inclination to adhere to PAP use. Consistent with the findings made here, Cai et al. (2014) in their study observed that patients with severe OSA are more likely to have positive attitude towards PAP and long-term usage of the intervention leading to reduced OSA-related hospital admission. This positive correlation between the severity of OSA and PAP adherence is also observed by Avellan-Hietanen et al. (2019) where the acceptance rate and of the latter was noted to increase with the deterioration of the former. The phenomenon is further investigated thoroughly and the inferred positive relationship between PAP compliance and OSA severity affirmed with scientific evidence by (Krakow et al. (2016), Jacobsen et al. (2017), Zampogna et al. (2019), Tepwimonpetkun et al. (2021), and Villa et al. (2021). In contrast, Luo et al. (2020) in their study noted that up to 40% of the cohorts diagnosed moderate to severe OSA expressed suboptimal adherence to PAP therapy. While Luo's et al observation is statistically significant, the

large discrepancy in the predictive effect of OSA severity on PAP adherence is attributed to limited disease awareness and titration experience with unmitigated risks.

While the observation is statistically significant, the large discrepancy in the predictive effect of OSA severity on PAP adherence is attributed to limited disease awareness and titration experience with unmitigated risks. The negative beta intercept indicates that the probability of predicting patient PAP adherence using the CCI is less than 0.5, which when holistically viewed together with other observations (alpha of .05, $\chi 2(1) = 0.97$, McFadden R^2 value = 0.01), strengthens the perception that the tool may have an insignificant effect on the odds of observing the category of PAP compliance or a measurement error may be present.

Research Question #3

Does the credential level of the sleep technologist or discharge planner predict PAP adherence in OSA patients?

The overall model indicates the credential level of the therapist or discharge planner has no significant effect on the odds of observing the one-category of PAP compliance. The beta coefficients of the three categories of the credential levels, including: RRT/CRT with sleep credentials, non-RRT/CRT healthcare provider with sleep credentials, and healthcare employees with no sleep credentials, have associated *p* values greater than 0.05 which is interpretively suggestive that the credential level of the sleep technologist or discharge planner is statistically insignificant in predicting PAP adherence in OSA patients. The odds ratio for predicting PAP adherence for RRT/CRT/CRTT with sleep credentials, non-RRT/CRT healthcare provider with sleep credentials, and healthcare employees are 15%, -4%, and 25.9% respectively. It is

impossible to tell with 95% confidence that RRT/CRT with sleep credentials have a statistically insignificant capacity to predict patient PAP adherence. However, there is a 95% confidence that credentialed healthcare professionals with sleep credentials have 53 to 95% odds of failing to predict patient PAP adherence. On the other hand, there is a 95% confidence that the ability of the credentialed healthcare employees with no sleep credentials to predict patient PAP adherence has 57 to 240% odds of being statistically insignificant. The registered dismal values of the model (alpha = .05, $\chi 2(2) = 0.29$, and McFadden's R^2 value = 0.00) further strengthen the inference that the credential level of the therapist does not have a significant effect on the odds of observing the one-category of PAP compliance.

Research Question #4

Does prior PAP failure predict current PAP adherence?

Prior PAP failure has a statistically significant effect on the odds of observing the one-category of PAP compliance. The model strongly suggests *with* $p < 0.001$ that past patient PAP adherence records can be used to successively predict their current and future PAP adherence behavior. An OR of previous failure predicting future success of .19 means that if you failed before you are 5.26x more likely to fail or 526% more likely to fail. The probability of getting a positive prediction exceeds 0.5.

Limitations

Several limitations became evident at the conclusion of this research study. The limitations of the data will be discussed first, followed by the limitation of the study design. The population of the data was a small representation, $n = 139$ of OSA patients who met the criteria at a local sleep facility. Although results were found, further

investigations are warranted to include a larger geographic patient population base to add power to any further investigations. However, while the sample size is limited, the sample was produced through random selection, which increases the external validity or generalizability of the results of the investigation's findings. Extrapolating the results of the study to the general population is difficult due to the unique demographic characteristics of the sleep facility being in a strictly suburban, rural area. The participants in the research study did not reflect racial and ethnic diversity. The lack of diversity among research participants could have research consequences that impedes the researcher's ability to generalize study results.

The second limitation was related to the racial makeup of the participant populations. African Americans represented 8.6% of the participants, while Caucasian participants represented 88.5% of the participants. Representation for males and females revealed an equal distribution within this investigation, with males at 56.1% and females at 43.9%.

The Epworth Sleepiness Scale (ESS) instrument used in the study is a self-reported measure of a patient's sleepiness; therefore, responses are limited to what individuals are willing to share. The ESS is also in English, so participants with a poorer understanding of the language may not have understood the questions properly. The reliability and validity of the Spanish translation of the instruments was not available.

Every attempt was exhausted to relegate bias within this study; however, bias is difficult to prevent, and some bias is inevitable. Transcription errors in the documentation process may also lead to incorrect data entered within the participants' EHR. These errors could have been unnoticed within the RCR data collection process, further lending to bias

within this investigation. However, the researcher was provided the data after all the data were recorded; therefore, minimizing any influence of researcher bias in the records.

Implications of This Study

It is feasible that if causation for PAP non-adherence was to be founded, an improvement and enhancement of patient care and quality of life could be realized. An improvement in patient satisfaction, outcomes, and quality of life, have roots in an improvement in PAP adherence as well. The feasibility of nominating PAP compliance as the gold standard for treating OSA has been explored extensively and supported by other researchers (Patil et al., 2019). Patients' adherence level is determined by marked expression of treatment tolerance and consistency. High levels of PAP adherence are severally correlated to extremely low residual AHI, high self-efficacy, and continuous PAP use for more than four hours per night (Gulati et al., 2015; Hiensch et al., 2016; Benjafield et al., 2019; Aardoom et al., 2020, Tran et al., 2021). Sustained PAP compliance has been shown to provide better quantitative therapeutic effects against the dose-dependent OSA leading to improved memory, low daytime sleepiness, improvement in critical cardiovascular parameters, and sleep latency (Woehrle et al., 2018). In Hussein et al. (2014) and Sutherland et al. (2018), it is noted that improving PAP compliance enhances patients' cognitive, metabolic, reduced risks of obesity, neurobehavioral, and cardiovascular functions. The empirical evidence presented in the literature adds credence to the observation made in the study that increasing PAP adherence provides a better chance for managing OSA compared to varying interventions or using alternative therapies.

Implications for education, practice, and research can be found in this study.

Unfortunately, in higher education, there is a deficiency in sleep-specific education for practitioners with many areas of credentialing opportunities. The general deficiency on sleep education in graduate medical education and medical schools curricula observed has been explored by other researchers. Ramar et al. (2021), for instance, reported a severe lack of sleep education in nursing curricula and certification in sleep medicine among physician assistants, regular nurses, and advanced practice registered nurses despite their significant role in frontline care. Retrospectively, medical schools globally reportedly spend an average of 2.5 hours on sleep education (Mindell et al., 2011). This creates a maze of practitioners who practice sleep medicine. The resulting acute knowledge gap on the management and importance of adequate sleep to safeguarding public health calls for urgent circadian research to lay bare the impact of the problem, impart practitioners with evidence-based skills, and enhance general knowledge the risks of sleep deprivation on public health and health-related quality of life.

Including a curriculum on sleep in all areas of medicine (e.g., nursing, respiratory, electro-neurodiagnostic, and medical school) is important for OSA patients and every patient with sleep issues. Education in the medical field should cover sleep disorders and the consequences of untreated sleep disorders to better prepare health professionals for their increasingly key role. Healthcare providers are in a unique position to educate patients about the effects of OSA. Educational intervention with patients at the time of diagnosis and treatment could also be effective in PAP adherence. Research supports that educational guidance before treatment and conducted after initiation of PAP improved adherence significantly (Boon et al., 2018).

Recommendations for Future Research

As mentioned previously, OSA has many negative health outcomes. Some of the most common ones include increased risk for cardiovascular comorbidity, motor vehicle crashes, and hypertension (Chiang et al., 2017). Additional studies to determine the prevalence and the effects of non-adherence to PAP therapy are warranted. A more comprehensive, randomized study may determine if other interventions (e.g., telemedicine education, technological, and behavioral interventions) can improve PAP adherence.

The following paragraphs are recommendations and suggestions to further investigate, develop, and confirm the findings of this research and the problematic issue of PAP adherence within the OSA patient population.

Further studies should be conducted to examine and quantify the role of how psychosocial factors modulate social and psychological variables on patient PAP adherence. Substantial focus must be focused towards understanding the correlation between patients' locus of control and motivation or willingness for PAP adherence. In relation to this, the cumulative effect of psychological factors (e.g., social desirability, depressive disorders, and stress and anxiety disorders) on patients' locus of control should be investigated to map the mental landscape and conditions that prompt PAP non-adherence and PAP adherence. Moreover, the modulating effect of social factors (e.g., positive feedback, partner sleep quality, and social support) on patients' locus of control should be explored to increase understanding of patients' complex thought processes to devise better and initiative-taking methods for motivating PAP adherence.

Additional research should explore and investigate creative, patient-centered, and culturally responsive interventions that can be employed to increase the rate of PAP adherence across all demographics. The suggested study should especially evaluate and appraise several categories of PAP-adherence interventions including cognitive behavior, educational, supportive, and mixed-strategy to establish their strength and effectiveness in promoting PAP adherence in each demographic. The key objectives of the study should be to quantify what works best for whom, when, where, and why to increase the efficiency of patient-targeting and subsequently drive the rate and uniformity of PAP adherence upward.

The correlation between patient past PAP adherence and current PAP adherence behavior should be investigated further to establish and analyze in-depth factors that modulate the predictive relationship and its response to environmental, psychosocial, and socioeconomic dynamics. The study should strive to discover and understand how the PAP adherence prediction of the patients vary across the demographic terrain.

Conclusion

The rate of OSA patients' PAP adherence is a key determinant of the quality and success of the healing and coping process, as well as the alleviation of comorbidities. A corpus of empirical studies on interventions for promoting PAP adherence have provided insight into theoretical underpinnings and practical solutions that may be effectively implemented to induce and accelerate the willingness, motivation, and commitment to adhere to the treatment therapy. Using the right tools and methods to predict the patients' PAP adherence raises the stake of successfully targeting interventions and efficiency of treatment. It is established here that analyzing patients' past PAP adherence behaviors

provide better predictive results on their current willingness to adhere to the therapy compared to the reliance on established tools (e.g., CCI) and the credential level of the sleep technologist or discharge planner.

The discrepancies in the effectiveness and efficiency of the three methods explored in the study are substantial. Extrapolating patient past records of PAP adherence to predict current PAP adherence behavior yields an add ratio of 81% and up to 58 to 92% probability of predicting right at the 95% confidence level. On the contrary, the other two methods perform dismally on both parameters with odds ratios for PAP adherence prediction ranging between 0 to 30%. Their probability of making successful prediction is less than 0.5 or 50%. This outcome suggests that patients' psychosocial behavior and locus of control can be quantitatively linked to patients' willingness and desire to follow through with their PAP treatment.

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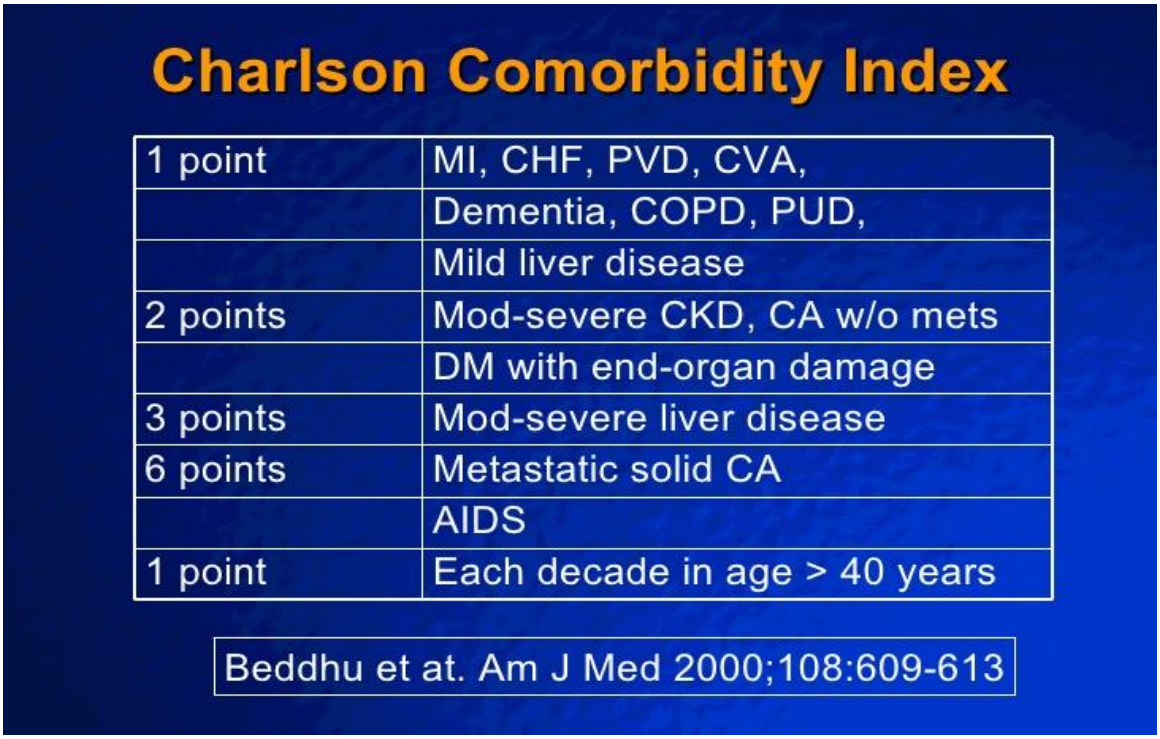
Appendix A

1 point	MI, CHF, PVD, CVA, Dementia, COPD, mild Liver Disease
1 point	Each decade in age >40years old
2 points	COPD, CA with mets, DM with organ damage
3 points	Moderate-Severe liver disease
6 points	Metastatic CA, AIDS



Appendix B

The Epworth Sleepiness Scale

The Epworth Sleepiness Scale is widely used in the field of sleep medicine as a subjective measure of a patient's sleepiness. The test is a list of eight situations in which you rate your tendency to become sleepy on a scale of 0, no chance of dozing, to 3, high chance of dozing. When you finish the test, add up the values of your responses. Your total score is based on a scale of 0 to 24. The scale estimates whether you are experiencing excessive sleepiness that possibly requires medical attention.

How Sleepy Are You?

For each situation, decide whether or not you would have:

· No chance of dozing =0

· Slight chance of dozing =1

· Moderate chance of dozing =2

· High chance of dozing =3

Write down the number corresponding to your choice in the right-hand column. Total your score below.

Situation:

Chance of Dozing

Sitting and reading ·

Watching TV ·

Sitting inactive in a public place (e.g., a theater or a meeting) ·

As a passenger in a car for an hour without a break ·

Lying down to rest in the afternoon when circumstances permit ·

Sitting and talking to someone ·

Sitting quietly after a lunch without alcohol ·

In a car, while stopped for a few minutes in traffic ·

Total Score = _____

Analyze Your Score

Interpretation:

0-7:It is unlikely that you are abnormally sleepy.

8-9:You have an average amount of daytime sleepiness.

10-15:You may be excessively sleepy depending on the situation. You may want to consider seeking medical attention.

16-24:You are excessively sleepy and should consider seeking medical attention.

This printed version of the Epworth Sleepiness Scale is provided courtesy of Talk About Sleep, Inc. www.talkaboutsleep.com.

Appendix C

Kelly Colwell
Health Professions 141208

Re: Exempt - Initial - 2022-13 Patient Adherence with Positive Pressure Used in the Treatment of Obstructive Sleep Apnea: Are Patient and Therapist level of Training Contributing Factors

Dear Dr. Kelly Colwell:

Youngstown State University Human Subjects Review Board has rendered the decision below for Patient Adherence with Positive Pressure Used in the Treatment of Obstructive Sleep Apnea: Are Patient and Therapist level of Training Contributing Factors.

Decision: Exempt

Selected Category: Category 4. Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

(i) The identifiable private information or identifiable biospecimens are publicly available;

(ii) Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects;

(iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of "health care operations" or "research" as those terms are defined at 45 CFR 164.501 or for "public health activities and purposes" as described under 45 CFR 164.512(b); or

(iv) The research is conducted by, or on behalf of, a Federal department or agency using government-generated or government-collected information obtained for nonresearch activities, if the research generates identifiable private information that is or will be maintained on information technology that is subject to and in compliance with section 208(b) of the E-Government Act of 2002, 44 U.S.C. 3501 note, if all of the identifiable private information collected, used, or generated as part of the activity will be maintained in systems of records subject to the Privacy Act of 1974, 5 U.S.C. 552a, and, if applicable, the information used in the research was collected subject to the Paperwork

Reduction Act of 1995, 44 U.S.C. 3501 et seq.

Any changes in your research activity should be promptly reported to the Institutional Review Board and may not be initiated without IRB approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly
reported to the IRB.

Findings: Exempt for pre-existing chart data. Letter of permission is provided.

The IRB would like to extend its best wishes to you in the conduct of this study.

Sincerely,
Youngstown State University Human Subjects Review Board