



Hidden Health Crisis Costing America Billions

*Underdiagnosing and Undertreating Obstructive Sleep Apnea
Draining Healthcare System*

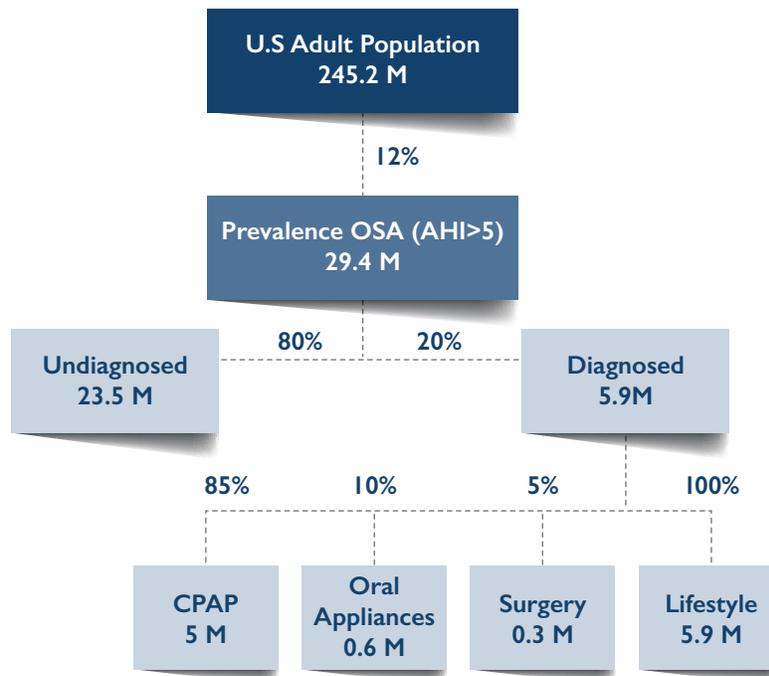
Executive Summary	3
Frost & Sullivan's Interest in OSA	4
How is OSA Diagnosed?	4
What is the Prevalence of OSA?	5
Barriers to Diagnosing & Treating OSA	6
Why is OSA So Undertreated?.....	7
OSA's Link to Life-threatening Comorbidities.....	7
Mental Health and Quality-of-life Benefits of Treating OSA	9
Productivity	10
Motor Vehicle and Workplace Accidents	10
Economic Impact of OSA for Payors.....	11
Economic Impact of OSA for Employers.....	12
Economic Impact of OSA for Patients	12
Investing in the Long-term Benefits of Diagnosing and Treating OSA	12
Employer Best Practices – Schneider	13
Insurer Best Practices	15
Research Methodology.....	18

EXECUTIVE SUMMARY

Imagine a news report of a government study showing that a life-threatening cancer present in 12% of adults goes untreated 80% of the time. Patient advocacy and public health organizations would have major concerns and launch widespread initiatives to address this massive diagnosis and treatment gap. Presently, obstructive sleep apnea (OSA), a serious and life-threatening sleep illness, fits this profile. The underdiagnosis and under-treatment of OSA is due to lack of education, underappreciation of the seriousness of the condition, and a healthcare system hyper-focused on acute illness; this is draining the US healthcare system of billions of dollars, while millions of patients suffer the chronic effects of this sleep disorder.

According to the American Academy of Sleep Medicine (AASM), OSA is characterized by repetitive episodes of complete or partial upper airway obstruction occurring during sleep and is often accompanied by daytime symptoms (e.g. sleepiness) or comorbid conditions (e.g. hypertension, type 2 diabetes mellitus).³ Approximately 5.9 million U.S. adults are diagnosed with OSA, but 23.5 million remain undiagnosed²⁸ (Figure 1). Direct economic costs can include comorbidities such as high blood pressure or diabetes, motor vehicle or workplace accidents, and compensating behaviors such as the substance abuse of pills, tobacco and alcohol. Indirect economic costs can include decreased productivity at work, reduced quality of life, and stress on interpersonal relationships.

Figure 1-Prevalence, Diagnosis and Treatment of OSA in the United States



Frost & Sullivan estimates that undiagnosed OSA cost the United States approximately \$149.6 billion in 2015. When calculating the respective costs for leaving OSA undiagnosed versus diagnosing and treating it, financial modeling indicates that treatment costs are approximately 33% of non-treatment costs resulting in a significant net cost savings to the nation (Figure 2).

Figure 2-Cost Burden of OSA in Undiagnosed Versus Diagnosis and Treatment Costs in the United States (2015)

	Undiagnosed		Diagnosed
# People with OSA	23,500,000		5,900,000
	Cost of Undiagnosed OSA (\$US Bil)		Cost of Diagnosed OSA (\$US Bil)
Comorbidities & Mental Health	\$30.0	Diagnosis, Testing and Follow-up	\$0.8
Motor Vehicle Accidents	\$26.2	Non-surgical Treatment (PAP and Oral Appliances)	\$6.2
Workplace Accidents	\$6.5	Surgical Treatment	\$5.4
Lost Productivity	\$86.9		
Total Costs (\$US Bil)	\$149.6		\$12.4
Cost per Person	\$6,366		\$2,105

Key opinion leaders and clinical researchers alike acknowledge that the economic impact of OSA on healthcare is high, but defining exact costs can be difficult. The condition can affect multiple areas of an individual's life, while remaining undiagnosed for years. There is growing clinical research demonstrating OSA's correlation with a multitude of health and quality of life indications; however, it can be difficult to define an exact cost to an individual symptom. Paul Peppard, Ph.D., leading public health professor at the University of Wisconsin School of Medicine and Public Health and principal investigator of the Wisconsin Sleep Cohort, explains the difficulty of estimating specific costs related to OSA: "More long-term research is needed to answer questions about the screening and diagnosis of OSA. It is hard to gauge the economic costs associated with OSA as it can affect productivity, heart disease, diabetes, high blood pressure, cognitive deficits, or car accidents."

FROST & SULLIVAN'S INTEREST IN OSA

Frost & Sullivan has been tracking the sleep medicine industry for the past decade, monitoring and contributing to the growing research of OSA. In such an established industry, we have focused our interest on the intersection of economics and current clinical research. Frost & Sullivan was commissioned by the AASM to investigate the dynamics of sleep apnea diagnosis and treatment, and its impact on healthcare and workplace economics in the United States. For the purpose of this paper, the team interviewed 14 key opinion leaders with specialties in economics, sleep medicine, productivity, mental health and accidents. In addition, the Frost & Sullivan research team reviewed more than 100 leading studies on the impact of the condition on everything from heart attack risk to employee absenteeism. Once completed, detailed financial models were constructed leveraging collected research, results from a Frost & Sullivan survey of 506 patients treating their OSA, and treatment fees pulled from CMS fee schedules, publically available sources, and prior research in the field.

HOW IS OSA DIAGNOSED?

OSA is most commonly diagnosed with either polysomnography (PSG) in a sleep center or a home sleep apnea test. Risk factors associated with OSA include obesity, wide neck circumference, aging, familial history, and facial or upper airway abnormalities. Treatment options include continuous positive airway pressure (CPAP), oral appliances therapy, surgery, and lifestyle changes such as weight loss or body positioning during sleep. OSA severity is divided into three categories based on the apnea-hypopnea index (AHI), which calculates the number of times an individual partially or completely stops breathing per hour of sleep³ (Figure 3).

Figure 3- OSA is Classified in One of Three Categories by Severity

Apnea-Hypopnea Index (AHI) ³	
Mild	AHI of 5-15
Moderate	AHI of 15.1-30
Severe	AHI >30

WHAT IS THE PREVALENCE OF OSA?

Frost & Sullivan estimates the prevalence of OSA to be 12% or 29.4 million of the U.S. adult population with nearly 80% of the population undiagnosed. Physicians, patients, payors, and employers are all economic stakeholders who may be unaware of the medical and financial impact of undiagnosed and untreated OSA. The general public lacks awareness of the health risks associated with OSA because they fail to link sleep apnea with its many serious comorbidities, such as increased rates of cardiovascular disease, diabetes, and accidents. Dr. Timothy Morgenthaler, patient safety officer at the Mayo Clinic, explains, “Many patients are dismissive of symptoms of sleepiness. It is accepted as the norm. Patients and providers need to acknowledge that OSA is a serious chronic disease just like hypertension and heart disease, and it needs to be managed.”



OSA incidence and prevalence is expected to rise with obesity rates; however, it is not solely related to obesity. Obstructive sleep apnea is more prevalent in individuals with factors that include being older, male, a minority race, have a high body mass index, large neck circumference, craniofacial abnormalities, are menopausal, and those with health behaviors such as smoking and alcohol use.³¹ Raising awareness and educating the general public is critical as there is a misconception that snoring or sleepiness is normal. Snoring is an indication of the airway narrowing during sleep, and as such, a warning sign of OSA. Dr. Nathaniel Watson, current AASM president, co-director of the University of Washington Sleep Center and director of the Harborview Medical Center Sleep Clinic, described the acuity issue: “Society undervalues sleep, instead valuing and lauding people that do not prioritize sleep because of a perception that they are more serious in their careers. Sleep apnea is associated with increased mortality, but it does not end up on anyone’s death certificate and thus the urgency to address the problem is not felt.”

BARRIERS TO OSA DIAGNOSIS AND TREATMENT

Perhaps the most significant barrier to treatment of OSA is patients' disregard of symptoms and their failure to report them to primary care physicians. Medical school training does not put an emphasis on sleep medicine, and as such, many providers do not recognize OSA symptoms or link disease-associated comorbidities or behaviors to sleep quality. Dr. Sonia Ancoli-Israel, professor emeritus of psychiatry at the University of California San Diego and director of the Veteran's Association Sleep Disorder Clinic, stressed the importance of provider/patient interaction. She said, "It all starts with one question that needs to be asked by every general practitioner: 'How are you sleeping?'" (Figure 4).

Figure 4 - Major Barriers to OSA Diagnosis & Treatment

General Public Awareness	Many individuals do not recognize symptoms and severity of the condition.
Primary Care Physician Education	Front-line caregivers do not routinely ask about duration and quality of sleep or screen patients for OSA.
Diagnosis and Treatment Costs	While usually covered by payors for qualified patients, costs average \$2,105 per year for testing, appointments, treatment devices and surgery if necessary.
Employer and Payor Investment for Chronic Care Management	Economic stakeholders are still developing cost models that financially reward managing chronic conditions in order to lessen longer-term risk for acute events

Once an individual is screened or informed about OSA, a significant financial and personal time investment is often necessary to address the problem. Diagnosis can involve multiple referral appointments and an overnight sleep test, which can be difficult for some individuals. Home sleep apnea testing, although less expensive and more convenient, lacks the sensitivity to rule out a sleep apnea diagnosis because it does not generally record sleep and wakefulness. Thus this test is only of value when positive. The accuracy of polysomnography in a sleep center versus home sleep apnea testing has been actively discussed in the medical community. Recent studies have shown a relative correlation between the two options when the home sleep apnea tests are performed under specific circumstances. At present, the use and reimbursement for both types of studies varies by region, payor and industry.

Frost & Sullivan estimates that the cost for diagnosing and treating OSA in the United States in 2015 was approximately \$12.4 billion. Approximately 7% of these costs are from physician office visits and testing which are necessary for diagnosis and ongoing management. Another 50% is generated from the sale and rental of positive airway pressure (PAP) machines and their accessories, as well customized oral appliances which a small portion of the population use. There are many different types of surgical treatments that may be appropriate for some patients with OSA from simple nasal reconstruction or tonsillectomy to palatoplasty, bariatric surgery and hypoglossal stimulation. Surgical costs for treating the condition are estimated to make the remaining 43% of costs. When considered across the 5.9 million U.S. residents in the country diagnosed with the condition, costs per OSA patient average \$2,105 per person per year. Most OSA patients do not require surgery, so when removing those costs the average drops to \$1,190. In context, this is less than the average cost of a single emergency department visit for a "moderate" problem (\$1,200) according to the Healthcare Bluebook. The payor community made up of insurers and employers has been slow to adopt aggressive OSA diagnosis and treatment. While there are initial investments, the cost of treating individuals with OSA is significantly less than leaving the condition untreated. Dr. Mark Berger, President and Chief Medical Officer at Precision Pulmonary Diagnosis (PPD) explains, "If you increase treatment and compliance of OSA long-term, you can decrease the severity of comorbidities, increase productivity and save on long-term healthcare costs."

WHY IS OSA SO UNDERTREATED?

Many individuals perceive OSA as unimportant and do not understand the extent of the impact it has on quality of life, productivity, and other aspects. For many people who have been living with the condition for an extended period of time, fatigue has become their baseline. Kevin Potts, vice president of Union Pacific Railroad Employees Health System (UPREHS), said, “It can be difficult to explain to people that treatment will make them feel better if they do not have the context to remember or recognize good quality sleep.”

Frost & Sullivan estimates that out of the 29.4 million U.S. adults with OSA, only 20% or 5.9 million individuals have been diagnosed. All individuals are prescribed lifestyle changes, which include weight loss or nocturnal body positioning as OSA is generally worse in the supine sleeping position. Additionally, 3% undergo surgery and 6% use oral appliances that are custom-fabricated, mouth guard-type devices that can help address OSA. Approximately 5 million people, or 85% of those diagnosed, receive the preferred treatment approach of PAP, whether it is CPAP, AutoPAP or Bilevel PAP. However, only 3 million or 60% will remain compliant with treatment protocols long term.



While there is limited information and long-term research to define economic costs definitively, it is still possible to link OSA to comorbidities, mental health, productivity and accidents. Dr. Michael Berneking, medical director of Concerta Health Systems, commented, “The expenses are staggering; the annual cost of OSA could be somewhere around \$165 billion, and not enough is being done about it. While the vast majority of costs are related to co-morbidities, the occupational sector is also affected as it results in lost productivity, market increases in healthcare utilization, and increased absenteeism.”

OSA'S LINK TO LIFE-THREATENING COMORBIDITIES

There is a growing body of research linking OSA prevalence with the increased likelihood of comorbidities such as diabetes, stroke, heart disease, and hypertension. Direct costs associated with comorbidities include increased medical expenses, emergency room visits, hospital inpatient visits, medication use, and mortality rates. Frost & Sullivan analysis of only the most well-understood comorbidities linked to OSA indicated that costs among the undiagnosed OSA population were approximately \$30 billion in the United States in 2015 (Figure 5). The model only considers medication and healthcare utilization costs, and only the portion of overall comorbidity costs that could be potentially avoided if OSA were treated.

Figure 5-Economic Impact of Comorbidities in Undiagnosed OSA Population in United States (2015)

Comorbidity	# People In U.S. with Undiagnosed OSA and Comorbidity (Mil)	Costs (\$US Bil)
Hypertension	14.1	\$5.4
Heart Disease	3.1	\$6.7
Diabetes	5.6	\$6.4
Asthma and Other Breathing Disorders	5.9	\$2.6
Insomnia	6.8	\$2.1
Depression, Anxiety and Other Mental Health Problems	8.7	\$7.1
Total	-	\$30.0

Costs include medication and healthcare utilization.

Hypertension

Approximately 70 million Americans are estimated to have hypertension or high blood pressure, equivalent to approximately one in three adults.²⁵ Approximately half of the adults diagnosed do not have the condition under control, leading to an estimated \$46 billion spent each year on related medical services, pharmaceuticals and absenteeism.²³ OSA is an independent risk factor for hypertension and evidence shows that CPAP treatment lowers hypertension risk.^{20,29} Dr. Javier Nieto, chairman of Population Health Sciences and Family Medicine at the University of Wisconsin School of Medicine and Public Health, has been investigating OSA for nearly 20 years. He said, “I believe there is solid evidence OSA is associated with cardiovascular events and mortality. It can be said with absolute certainty that treating OSA reduces blood pressure, therefore reducing hypertension.”

Heart Disease, Diabetes, Stroke and Asthma

Approximately 26.6 million adults are diagnosed with heart disease, and it is the leading cause of death in the US with 610,000 adults dying from this condition each year, costing an estimated \$108.9 billion annually.^{7,11} Severe OSA has been associated with sub-clinical coronary heart disease independent of traditional demographics and risk factors, such as smoking and obesity.¹⁹ A large study in Spain on men with varying severity and treatment of sleep apnea demonstrated that untreated severe sleep apnea significantly increased the risk of fatal and non-fatal cardiovascular events when compared to healthy participants. Equally important, the study found that CPAP treatment reduces this risk.²¹

Diabetes affects approximately 29.1 million Americans, costing approximately \$245 billion for the 21 million who are diagnosed.⁸ Adequate sleep, or lack thereof, has been shown to affect metabolic pathways and the degree of glucose intolerance and insulin resistance. An increasing number of observation and experimental studies suggests that habitually shortened sleep duration or disturbances of sleep, caused by conditions such as sleep apnea, may increase risk for metabolic dysfunction.⁴ Two studies from the European Respiratory Journal found a significant relationship between diabetes and OSA. One report found that metabolic syndrome is higher in individuals with OSA, and that CPAP treatment appears to improve glucose metabolism.¹⁶ A second report found that Type 2 diabetes and glucose intolerance were present in 30.1% and 20% of OSA patients, respectively.²² Hypertension, heart disease, diabetes and obesity are all contributing factors to stroke, the fifth-leading cause of death in the U.S., killing nearly 130,000 adults each year.¹⁸

In a recent report published by the U.S. Centers for Disease Control (CDC), approximately 8% or 19 million U.S. adults reported having asthma, costing an estimated \$20.7 billion each year.³² One report found that individuals who are high risk for OSA were 2.87 times more likely to have insufficient asthma control.³⁴ Increased research on breathing disorders has found that individuals with inadequate asthma control should be screened for OSA.

MENTAL HEALTH AND QUALITY-OF-LIFE BENEFITS OF TREATING OSA

A person's mental health includes cognitive function, quality of life (QOL), mood, depression, energy levels, and satisfying interpersonal relationships. Mental health disorders affect nearly 13 million or one in 17 U.S. adults and are the leading cause of disability in the country.³⁵ Recent research is showing the corresponding relationship between physical and mental health. Chronic diseases like OSA, which are major limiting factors on physical health, decrease the likelihood of individuals establishing health-promoting behaviors.¹⁵

According to a study review authored by the Minnesota Regional Sleep Disorders Center, in both the community and clinical settings there is a higher prevalence of depression in people with OSA.¹⁰ The direct relationship between depression and OSA is unclear at present, but numerous studies show symptom overlap between these two diseases. Fatigue and drowsiness, two of the main OSA symptoms, can be associated with many mental health conditions. Snoring, another OSA symptom, can lead to sleep disturbances, and according to a study performed by the Mayo Clinic, impaired quality of life for both the patient and their bed partner.²⁷ Patients treated for their OSA show improvements in QOL when supported with physician follow-up and increased communication throughout treatment.¹³



Research shows that individuals with low-quality sleep may turn to compensating behaviors such as alcohol abuse, excessive use of energy products (pills, drinks) and sleeping pills, and tobacco consumption. A study published in the Chinese Medical Journal stated smoking increases risk for OSA and conversely OSA may pre-dispose to smoking.¹⁷ The National Institute of Health published a report 15 years ago describing how alcohol consumption can induce sleep disorders and alcoholism can increase one's risk of OSA.² Lastly, a Loyola study found that lack of physician education on OSA leads to misdiagnosis and the prescription of unnecessary and potentially harmful sedating medications.¹⁸

PRODUCTIVITY

Productivity is an umbrella term for situations such as absenteeism, underperformance, and negative workplace behavior. Frost & Sullivan estimates that untreated OSA in the United States resulted in a loss of productivity estimated at \$86.9 billion in 2015. By this measure, lost workplace productivity represents 77.4% of the total cost burden of OSA. Frost & Sullivan's recent survey of people treating their OSA found that for those people who were employed, absences declined by 1.8 days per year and productivity on the job increased by 17.3% on average. When taking into consideration average wages and extrapolating that impact out to the 10.6 million working Americans with undiagnosed OSA, the economic impact is enormous. Employers are paying billions of dollars in wages for work time from employees who are not fully present physically or mentally due to OSA. According to a study at the University of California San Francisco, OSA was found to contribute to both work disability and decreased productivity²⁶. Absenteeism and work disability are quantifiable metrics an organization can monitor to gauge loss of income, but determining which cases are specifically attributed to OSA can be difficult to segment out.

Christopher Barnes, Ph.D., associate professor of management at the University of Washington, has produced multiple studies demonstrating that loss of sleep can affect productivity. One hour of sleep lost, even from something as seemingly insignificant as Daylights Savings Time, can result in "cyberloafing," poor decision making, decreased productivity, and the degree of likelihood that an individual will help a colleague.⁵ While the impact of OSA varies by employer, all effect economic productivity. Barnes explains, "It's hard to quantify what one hour of work costs as there are too many variables of industry, but we can link both lack of sleep and poor quality sleep to decreased productivity."

MOTOR VEHICLE AND WORKPLACE ACCIDENTS

The total economic impact of all motor vehicle accidents in the United States where undiagnosed OSA was a contributing factor was estimated at \$26.2 billion in 2015. Cost savings realized from improved OSA diagnosis and treatment include the reduction of vehicular damages, lost wages from corresponding absenteeism, property damage, rising insurance premiums and medical expenses for those accidents where drowsiness was a contributing factor. There were 1.1 million U.S. motor vehicle accidents in 2014 according to the Federal Motor Carrier Safety Administration (FMCSA)¹. The National Highway Traffic Safety Administration (NHTSA) estimates that more than 10 million accidents go unreported each year. According to a report by AAA, drowsy driving causes nearly 29% or 328,000 crashes, resulting in 1,090 injuries and 6,400 fatalities each year³³. Fatigue and drowsiness have been tied to transportation accidents in a number of studies and large scale accidents. Since drowsiness and OSA are highly correlated, individuals with OSA have higher motor vehicle accident rates, especially those associated with personal injury.²⁴

One example of operator fatigue related to OSA was an accident that occurred near Chaffee, Mo., in May 2013. Two freight trains collided resulting in fires, a collapsed bridge and multiple injuries. According to an accident report released in November 2014 by the National Transportation Safety Board (NTSB), the probable cause was due to the train operator's fatigue-induced performance degradation with estimated damages at more than \$11 million. Probable causes were listed as the lack of: "Medical screening requirements for employees in safety-sensitive positions for sleep apnea and other sleep disorders, and action by the Federal Railroad Administration to fully implement the fatigue management components required by the Rail Safety Improvement Act (RSIA) of 2008. Likely contributing to the engineer's fatigue was undiagnosed obstructive sleep apnea."⁹ The RSIA was enacted in response to several fatal rail accidents, specifically a deadly collision in 2008 near Chatsworth, Calif., where a passenger and freight train collided, resulting in more than 100 injuries and 25 fatalities.

The danger of undiagnosed and untreated OSA in the transportation industry is intensified since trucks, trailers, trains and airplanes can cause a greater threat to public safety than standard passenger vehicles. These incidents can be extremely costly and many times tragic for the individuals and employers involved. Each sector of the industry has its own employee health guidelines, but without a mandated federal screening program, many employers, payors and practitioners are not incentivized to diagnose and treat OSA.

Highlighting the importance of this issue, in March 2016 the U.S. Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) and Federal Railroad Administration (FRA) announced in the Federal Register an advance notice of proposed rulemaking and a request for public comments related to the problem of OSA among workers in the transportation industry. The administrations were seeking comments on the prevalence of the condition, the costs and benefits related to managing the condition and people with it, screening procedures and diagnostics, medical personnel qualifications and restrictions, and treatment effectiveness.

Berneking explained the current process, saying, "There are standards and recommendations set by the government for practitioners who perform annual examinations on transportation employees. However, these recommendations do not carry enough weight as it is up to the expertise of the medical examiners to enforce sleep apnea guidelines."

Frost & Sullivan defined "workplace accidents" as non-vehicular incidents. Costs for these accidents due to undiagnosed and untreated OSA totaled \$6.5 billion in 2015. A study in 2009 found that just one hour of lost sleep resulted in a 5.7% increase in workplace injury and 67.6% increase in days of work lost due to the sustained injuries⁵. Another study found that people with OSA were nearly twice as likely to be hurt on the job¹². Associated costs can be very expensive affecting not only the individual and employer but also the entire healthcare industry and tax payers. For individuals severely injured, returning to work may not be an option due to physical or mental constraints. Treatment cost savings include reduced lost wages and absenteeism, lower associated medical expenses and better quality of life.

ECONOMIC IMPACT OF OSA FOR PAYORS

While Frost & Sullivan estimates that approximately \$12.4 billion was spent in 2015 diagnosing and treating OSA for the 5.9 million U.S. adults diagnosed with the condition, a larger and more significant investment of approximately \$49.5 billion would be necessary every year to care for the 23.5 million individuals with OSA who are undiagnosed today. While the direct upfront costs of diagnosis and treatment are present, they are substantially lower than the costs associated with leaving the condition untreated.

Frost & Sullivan believes this cost has led some payors to not aggressively promote their OSA diagnosis and treatment programs. Individuals may change insurance provider year to year depending upon employment or other variables, and this can disincentivize payors from investing upfront in treating chronic conditions since they may not be able to realize the long-term savings from interventions they invest in. However, the costs associated with unaddressed OSA are not limited to late in life. Payors adapting to new models in population health management and other models that reward preventive care are at the forefront of investing in OSA diagnosis and treatment programs. Dr. Christian Guilleminault, professor of psychiatry and behavioral sciences at Stanford School of Medicine, explains, "There is a growing body of research linking obesity with OSA, which can lead to cardiovascular, cognition and mood-related problems. Everyone agrees that sleep apnea exists; the issue is who is paying for it."

Innovative health plans such as Humana* have taken a new approach in OSA diagnosis and treatment by creating educational programs for members. Delivered through a variety of communication vehicles, these programs provide resources to build awareness and address barriers to treatment. Heather Miller, program manager for the Clinical

Best Practices team at Humana* discussed the outreach provided, “We focus on our members with chronic conditions who may be at risk for OSA, offering tools to self-assess based on their current symptoms. We also work with our providers, highlighting additional information on advancements in research and technology, and provide our members tips and answers to questions that help facilitate the conversation with their doctor. To lessen the economic impact of OSA, we are trying to close the gap among the undiagnosed population and engage those not actively managing their OSA.”

The shift from fee-for-service to value-based care has resulted in more bundled payments that reward systems for providing outcomes-based care. Instead of reimbursing for each physician visit, diagnostic test, treatment trial, and follow-up visit, the payor would reimburse the entire process in one lump sum. If a patient is diagnosed and treated more efficiently with a successful outcome, they could be reimbursed at a greater degree. This may incentivize more cost-effective management systems and processes, such as case manager programs, as well as the use of innovative technology.

*Footnote: In July 2015, Aetna announced an agreement to acquire Humana. The transaction is expected to close in the second half of 2016.

ECONOMIC IMPACT OF OSA FOR EMPLOYERS

Companies interviewed by Frost & Sullivan that are aggressively targeting OSA have seen substantial cost savings by reducing workplace absences, better managing comorbidities, and increasing productivity. According to a Frost & Sullivan survey of 506 U.S. patients actively treating their OSA, there was a reported 40% decline in workplace absences and 17.3% increase in productivity after OSA treatment was initiated. These benefits are being realized by a number of companies and payors who are investing in sleep apnea diagnosis and treatment, such as AAA Foundation, Aetna, Alphabet (Google), Concerta, Humana, Huffington Post, Kaiser Permanente, Schneider, and UPREHS.

ECONOMIC IMPACT OF OSA FOR PATIENTS

Treating OSA is an investment in long-term health. Patients are able to reduce their healthcare utilization and save money by reducing the impact of OSA symptoms, comorbidities, and accidents. According to the Frost & Sullivan patient survey, direct medical costs and co-pays decrease for patients who treat their OSA under the guidance of a physician. However, self-medication of OSA symptoms can lead to the use and, in some cases, abuse of alcohol, cigarettes and sleeping pills. According to our patient survey, 31% of respondents had fewer alcoholic drinks, 62% smoked fewer cigarettes, and 21% used fewer sleeping pills following OSA diagnosis and treatment. Comorbidities associated with OSA such as hypertension and diabetes pose a significant financial burden, which continues to rise. According to the same survey, approximately 3% of hypertensive patients with OSA were able to stop and another 17% were able to decrease medication after receiving treatment. For diabetics treating OSA, hospital visits were cut nearly in half from 2.8 to 1.5 annually. The overall reduction in medication use and annual hospital visits in examples such as this saves patients millions of dollars each year. Approximately 78% of survey respondents stated OSA treatment was a good investment.

INVESTING IN THE LONG-TERM BENEFITS OF DIAGNOSING AND TREATING OSA

The next decade looks promising for OSA diagnosis and treatment. Research focused on the value of quality sleep and the negative effects of sleep deprivation are becoming more widely accepted. New tools such as telehealth, predictive analytics and personalized medicine, which can determine the best treatment for an individual, will allow physicians to deliver better care. More accurate and convenient home sleep apnea testing, a rapidly developing consumer sleep technology market, and wireless CPAP compliance monitoring are also expected to increase the successful diagnosis and treatment of OSA.¹⁴

Dr. Dennis Hwang, co-chair of sleep medicine at Kaiser Permanente, elaborates, “We are attempting to close the loop in OSA management with comprehensive care and technology integration. It is important to invest in the care of patients before they come in for diagnosis, so we are sending electronic educational programs which discuss what OSA is and how it is treated. Screening or risk identification is another area that needs to be developed, especially for patients who have heart disease or about to undergo surgery. However, emphasizing diagnostics is not enough; the follow-up is also critical. Providers are responsible for managing the patient’s sleep disorder indefinitely, so to better manage the growing volume, it is important to train providers or case managers outside of the traditional sleep physician. These case managers can assist with follow-up and other CPAP maintenance needs.”

While the broader U.S. healthcare system continues to adapt to the needs of OSA patients, the transportation industry is on the leading edge of the field and has found success in more holistic patient care models. Employers and payors in this industry place a greater emphasis on OSA care since they have significant employee retention interests and understand the public health and economic impact of OSA-related transportation accidents on society. Lessons learned in the transportation industry have much to teach regarding the value of OSA diagnosis and treatment. Frost & Sullivan has chosen to highlight the best practices of an employer and payor that testify to the cost-saving benefits of treating OSA.

EMPLOYER BEST PRACTICES – SCHNEIDER

COMMITMENT TO EMPLOYEE HEALTH AND SAFETY

Schneider is one of the leading trucking and logistics services companies in North America and China. The company’s commitment to employee health and safety has created an innovative and comprehensive program for the diagnosis and treatment of OSA. In the commercial trucking industry, accidents are one of the most dangerous and costly events. According to a recent report from the FMCSA, 3,806 fatal and 385,000 nonfatal crashes in 2013 were caused by large buses and trucks.¹ This accounted for nearly 12.7% and 6.8% of total motor vehicle accidents in the U.S., respectively. The average cost of a commercial trucking accident ranges from \$97,000 for a small-sized truck to \$512,000 for a medium-sized truck pulling two to three trailers. The cost of a fatal truck accident is significantly more, averaging over \$7 million each.

DEDICATION TO OSA

Thomas DiSalvi, vice president of safety and loss prevention at Schneider, explains the program: “[Schneider] has long acknowledged the link between driver fatigue and its impact on performance. It is ultimately a safety perspective. OSA management is a part of our culture, and we support various treatment and compliance programs. We have approximately 2,700 drivers currently on CPAP and they can all receive follow-up appointments or devices at any one of our 35 clinics around the country.”

Schneider’s dedication to OSA led it to partner with Precision Pulmonary Diagnosis (PPD), an organization that specializes in the management of sleep apnea in the professional driver community. Commercial drivers often ignore symptoms related to sleep apnea and fatigue since they often fear it could lead to job dismissal. Berger discussed the partnership, saying, “We launched a model with Schneider in 2006 that integrated the screening, diagnosis and treatment of sleep apnea for truck drivers. Over the last 10 years, over 70,000 drivers have taken the screening questionnaire. Approximately 95% of commercial drivers screened denied overt signs and symptoms of sleep apnea and fatigue, but over 85% tested positive of having an AHI of 5 or greater.”

COST SAVINGS FROM OSA TREATMENT

The ability to flag at-risk OSA patients, screen and treat them from anywhere in the country has resulted in significantly improved employee health and safety at the company. Schneider has been able to integrate OSA management and CPAP compliance into its culture, and positive results were demonstrated in a 2012 study on commercial drivers with sleep disordered breathing (SDB), which can include snoring and OSA. Among employees being actively treated with CPAP, Schneider and PPD saw a 73% reduction in preventable driving accidents.⁶ Assuming results similar to Schneider's, potential annual cost savings for a hypothetical small trucking company with 1,000 employees could be approximately \$19.1 million, and for a large trucking company with 11,000 employees up to \$1.2 billion (Figure 6). According to Berneking, "A large commercial truck crash can cost up to \$9 million, but if drivers were screened and subsequently treated for OSA, up to \$11 billion annually could be saved."

Figure 6 - Potential Cost Savings for Two Hypothetical Trucking Companies Treating Drivers with SDB Using CPAP

Potential Cost Savings: Commercial Driver Accidents				
Cost of Accident: Non-fatal Small to Medium-sized Trucks with 2-3 Trailers (assuming 99% of all commercial accidents) ¹	\$304,500			
Cost of Accident: Fatal Semi-truck (assuming 1% of all commercial accidents) ¹	\$7,000,000			
	Small Trucking Company		Large Trucking Company	
# Company Drivers	1,000		11,000	
Commercial Drivers with SDB ^{*6}	190		2,090	
	Treated on CPAP	Untreated	Treated on CPAP	Untreated
Annual Accident Rate: Commercial Drivers with SDB	10%	37.2%	10%	37.2%
# Accidents Per Year: Commercial Drivers with SDB	19	71	308	1,146
Cost of Company's Accidents: Non-Fatal Small to Medium-Sized Trucks with 2-3 Trailers	\$5.7 M	\$21.3 M	\$92.9 M	\$1.1 B
Cost of Company's Accidents: Fatal Semi-truck	\$1.3 M	\$4.8 M	\$21.1 M	\$250.3 M
Annual Cost Savings for Commercial Drivers Treated on CPAP				
	Small Trucking Company		Large Trucking Company	
Small to Medium-Sized Truck Non-Fatal Accidents ^{**}	\$15.6 M		\$1.0 B	
Fatal Semi-Truck Accidents ^{**}	\$3.5 M		\$229.1 M	
Total Annual Difference	\$19.1 M		\$1.2 B	
*Assuming moderate case scenario where 19% of commercial drivers have SDB				
** Untreated Drivers – Treated Drivers = Annual Cost Savings				
Note: Accident costs include: Medical costs, emergency services, property damage, lost productivity, and monetized quality adjusted life (QALYs) incurred by company, insurer, victims, government and others.				

In the same report, Schneider and PPD found significant healthcare utilization cost savings by treating OSA. For drivers diagnosed with OSA and being treated with CPAP, an average of \$550 per driver per month was saved.⁶ Hospital admissions were reduced by nearly 25% and overall healthcare dollars spent were cut in half (Figure 7). DiSalvi explains, “It is very difficult to quantify sleep apnea vigilance, but [Schneider] can quantify the benefit from a medical costs perspective. We can fund the expense of OSA diagnosis and treatment just by generating savings on the medical side.”

Figure 7 - Potential Cost Savings per Member for Two Hypothetical Commercial Trucking Companies by Treating SDB Using CPAP

Potential Cost Savings: Commercial Drivers		
	Small Trucking Company	Large Trucking Company
# Company Employees	1,000	11,000
Estimated Commercial Drivers with SDB ^{6*}	190	2,090
CPAP Treatment average annual cost savings (per member) ⁶	\$6,601	\$6,601
Annual Cost Savings for Commercial Drivers with SDB	\$1.3 M	\$13.8 M
<i>*Assuming moderate case scenario where 19% of commercial drivers have SDB</i>		

INSURER BEST PRACTICES

COMMITMENT TO MEMBER HEALTH AND SAFETY

Union Pacific Railroad Employees Health System (UPREHS) was established in 1862 and insures more than 20,000 rail workers across 30 states. With lifetime member benefits offered after 30 years of service, many employees are insured by UPREHS from their first day of work until the day they die. This large and longstanding patient population has given the company unique insight into long-term health benefits, ultimately incentivizing it to create preventative health and wellness programs. As stated by UPREHS Vice President Kevin Potts, “Anything we invest in now will benefit us in the future. Treating OSA lowers healthcare dollars spent and medical costs while improving employee quality of life.”

DEDICATION TO OSA

UPREHS created a designated OSA program, “Complete Sleep,” almost 10 years ago to use CPAP treatment of OSA to lower long-term healthcare costs. The company has tailored Complete Sleep to its predominately male workforce, implementing risk assessments at yearly physicals, providing home sleep apnea testing, and offering remote follow-up practices.

COST SAVINGS FROM OSA TREATMENT

Due to the stability and longevity of the members enrolled in their health plan, UPREHS has been able to publish two papers on the cost savings of those treated with CPAP. The studies showed that approximately \$200 per member per month is realized when an individual is actively treated with CPAP³⁰ (Figure 8). The long-term savings could be much higher than reported if the effect of comorbidities such as diabetes and hypertension were lessened as well.

Figure 8 - Potential Cost Savings for a Hypothetical Health Payor Covering SDB Treatment

Potential Cost Savings: Hypothetical Payor	
# Members	10,000,000
Members with Sleep-disordered Breathing (SDB) ^{30*}	1,200,000
Annual Medical Cost of All Members with SDB Before CPAP (\$9,000 each per year)	\$10.80 billion
Annual Medical Cost of All Members with SDB After CPAP (\$6,600 each per year)	\$7.92 billion
Annual Cost Savings for Members Treated with CPAP	\$2.88 billion
<i>*Snapshot of all members who currently have SDB</i>	

HOW DO WE BEND THE OSA COST CURVE?

If OSA-related health costs remain unchecked, the United States will continue to incur billions of dollars in unnecessary expenses. Reducing these costs requires a multidisciplinary approach that involves many constituency groups, including patients, families, physicians, payors, employers and government agencies. The current U.S. healthcare system is highly fragmented and shaped around managing acute care episodes versus a more holistic and long-term approach to health and wellness. For a condition like OSA, where cost implications are sometimes hard to determine and spread over many years and millions of people, it can be much more difficult to raise awareness compared to a smaller number of acute conditions with clearer clinical implications. Despite these challenges, now is the time for all stakeholders in the healthcare system to make a commitment to shrinking OSA's impact, which continues to sap our country not just of dollars, but also lives, productivity and vitality.

What Can We Do to Help Address the Economic Impact of Undiagnosed OSA?

PATIENTS

- Patients should talk with their doctor about their OSA risk level, and seek diagnosis and treatment as soon as possible. Family members should likewise be evaluated since some risk factors are common among families.
- Patients should be encouraged and motivated to find the treatment options that work best for them over the rest of their lives.

PRIMARY CARE AND NON-SLEEP SPECIALISTS

- As many individuals are impacted by sleep disorders, sleep medicine training must play a larger role in the education of physicians, nurses and allied health.
- Physicians must become better educated on the indicators for OSA, as well as the available diagnostic and treatment options. OSA is life-threatening and contributes to the morbidity and mortality of other serious chronic conditions. It costs patients and payors money, and stands in the way of patients having a happier, healthier, and more productive life.
- Improved screening tools, patient education materials, and other supporting technologies should become more broadly available to primary care providers to help them address OSA.
- Create more integrated care teams across medical specialties to treat OSA and measure its impact on comorbidities. Involve non-physicians, such as dentists and behavioral health specialists, in care decisions.

SLEEP PHYSICIANS

- Teaching hospitals should support and grow fellowship training programs to grow the field of sleep medicine. This includes not only physicians, but also technologists, nurses and allied health necessary to support the diagnosis and treatment of OSA.
- Leverage significant advances in telehealth, wearable technology, surgery and other fields to create better diagnostic and treatment approaches to OSA that are simpler, less invasive and less expensive.
- Improve sleep center efficiency and productivity to grow testing capacity.

EMPLOYERS, GOVERNMENT AND INSURANCE PROVIDERS

- Consider adoption of more aggressive and comprehensive OSA diagnosis and treatment programs.
- Conduct deeper analysis on the true economic impact of OSA across all comorbidities and healthcare utilization within your populations.
- Improve reimbursement and other appropriate financial incentives to encourage providers to actively screen for and diagnose OSA.
- Create awareness and screening programs targeted at underserved patient populations. Partner with occupational and public health providers. Consider ways to lower financial barriers to accessing testing and treatment.



RESEARCH METHODOLOGY

Cost Burden of Undiagnosed OSA

The total cost impact of OSA in the United States was assumed to be made up of four components, each calculated with their own method. A confidence level was assigned to each component reflecting Frost & Sullivan's assessment of what the low and high-end estimates of costs are likely to be based on unknown quantities related to epidemiology, cost and access to care.

I) Comorbidities & Mental Health (+/- 30%)

The total cost impact of comorbidities and mental health were assumed to consist of the following six conditions which clinical literature has shown to have a strong connection to OSA.

- I. Hypertension
- II. Heart Disease
- III. Diabetes
- IV. Asthma and Other Breathing Disorders
- V. Insomnia
- VI. Depression, Anxiety and Other Mental Health Problems

Cost for each comorbidity was calculated in the following way:

Comorbidity Cost Factors	
Prevalence of Comorbidity	A
Total National Cost Burden for Comorbidity	B
Total Cost of Comorbidity Per Person	$C = B / A$
Number of Individuals with Undiagnosed OSA	D
Prevalence Percentage of Comorbidity in Individuals with OSA	E
Total Number of Individuals with Undiagnosed OSA and the Comorbidity	$F = D \times E$
Percentage of Individuals with the Comorbidity Who Show Improvement with OSA Treatment	$G = E \times F$
Total Cost of Comorbidity Directly Related to Undiagnosed OSA	$H = C \times G$
<i>Note: This applies to the United States only</i>	

2) Motor Vehicle Accidents (+/- 20%)

The total cost impact of motor vehicle accidents was assumed to consist of the following two categories which literature and government data sources have shown to have a strong connection to drowsiness and OSA.

- I. Commercial Accidents
- II. Non-commercial Accidents

Motor Vehicle Accident Cost Factors	
Cost of Commercial Small to Medium-Sized Trucks with 2-3 Trailers Accidents	A
Cost of Commercial Fatal Semi-truck Accidents	B
Total Cost of Commercial Accidents	$C = A + B$
Percentage of Motor Vehicle Accidents Where Undiagnosed OSA a Factor	D
Total Cost of Commercial Accidents Due to Individuals with Undiagnosed OSA	$E = C \times D$
Cost of Reported Non-commercial Non-fatal Accidents	F
Cost of Reported Non-commercial Fatal Accidents	G
Total Cost of Reported Non-commercial Accidents Due to Individuals with Undiagnosed OSA	$H = (F+G) \times D$
Total Cost of Non-reported Non-commercial Accidents Due to Individuals with Undiagnosed OSA	$I = 10\% \times H$
Total Cost of Motor Vehicle Accidents Where Undiagnosed OSA a Contributing Factor	$J = E + H + I$
<i>Note: This applies to the United States only. All commercial accidents reported. Accidents where OSA is contributing assumed to only occur with undiagnosed OSA, assuming that diagnosed OSA is well managed to the point of not being a contributing factor.</i>	

3) Workplace Accidents (+/- 30%)

The total cost impact of workplace accidents was assumed to consist of non-motor vehicle-related workplace injuries which literature and government sources have shown to have a strong connection to OSA.

Workplace Accident Cost Factors	
Number of Workplace Injuries	A
Cost of Single Workplace Injury	B
Total Cost of Workplace Injuries	$C = B / A$
Prevalence of OSA in Employed Population	D
Incidence Rate of Workplace Injury Among Fatigued Workers	E
Number of Workplace Injuries Due to Undiagnosed OSA	$F = A \times D \times E$
Total Cost of Workplace Accidents for Individuals with Undiagnosed OSA	$G = B \times F$
<i>Note: This applies to the United States only. Accidents where OSA is contributing assumed to only occur with undiagnosed OSA, assuming that diagnosed OSA is well managed to the point of not being a contributing factor.</i>	

4) Productivity (+/-30%)

The total cost impact of lost productivity due to undiagnosed OSA was assumed to include the cost of increased absences as well as decreased productivity while employees were on the job. Data from the Bureau of Labor Statistics and Social Security Administration were used to determine average wages for both hourly and salaried workers.

Productivity Cost Factors	
Percent of Individuals with OSA Employed	A
Number of Individuals with Undiagnosed OSA	B
Total Number of Individuals with Undiagnosed OSA Employed	$C = A \times B$
Percentage of U.S. Workers Who are Hourly	D
Percentage of U.S. Workers Who are Salaried	E
Total Number of Individuals with Undiagnosed OSA Employed as Hourly Workers	$F = D \times C$
Total Number of Individuals with Undiagnosed OSA Employed as Salaried Workers	$G = E \times C$
Average Number of Absences from Work per Year Due to OSA	H
Average Hourly Pay for Hourly Workers	I
Average Annual Salary for Salaried Workers	J
Costs Due to Undiagnosed OSA-related Absences Among Hourly Workers	$K = ((8 \times I) \times H) \times F$
Costs Due to Undiagnosed OSA-related Absences Among Salaried Workers	$L = ((J/246) \times H) \times G$
Total Costs Due to Undiagnosed OSA-related Absences Among All Workers	$M = K + L$
Percentage of Workday Considered Unproductive by OSA Patients Due to OSA Symptoms	N
Costs Due to Unproductive Work Time Among Hourly Workers with Undiagnosed OSA	$O = ((N \times I) \times 35 \text{ hrs p/wk} \times 50 \text{ wks p/yr}) \times F$
Costs Due to Unproductive Work Time Among Salaried Workers with Undiagnosed OSA	$P = (N \times J) \times G$
Total Costs Due to Unproductive Work Time Among All Workers with Undiagnosed OSA	$Q = O + P$
Total Cost of Lost Productivity Due to Undiagnosed OSA	$R = M + Q$
<i>Note: This applies to the United States only</i>	

Costs Associated with Diagnosis and Treatment of OSA

Total diagnosis and treatment costs calculated as the sum of the following:

I. DIAGNOSIS

- A. Number of OSA patients initially diagnosed in 2015 estimated based on survey of 506 OSA patients receiving treatment.
- B. Diagnostic care pathway mapped out based on what percentage of patients receive in-center PSG testing (standard versus split night) versus home sleep apnea testing (HST), which requires confirmatory in-center PSG for some patients. Conservative and aggressive scenarios were developed, which applied different assumptions on the utilization rates of different testing types. The following procedures and related HCPCS codes were mapped:

- Home Sleep Apnea Testing (95806)
 - In-center PSG (95810)
 - In-center PSG (Split Night) (No HST) 95811
 - Clinic Visit (One Diagnosis Appointment and Two Follow-up in First Year) (Average of 99201-99205)
- C. To determine pricing, Frost & Sullivan used the HCPCS 2015B fee schedule for diagnostic services at the “Facility” price and the global value for both professional and technical components. Researchers designated MAC locality “0” for a national average, applied Medicare costs to the 24.1% of the diagnosed OSA population Medicare/Medicaid eligible, added a 25% premium to Medicare fees to develop private insurance fee rates based on 2014 research by the Commonwealth Fund, then applied those costs to the remaining 75.9% of patients.
- D. For patients already diagnosed with OSA before 2015, only costs for a single annual clinic visit were applied using an average fee of HCPCS 99211-99215. The same assumptions applied as for those initially diagnosed in 2015. No testing beyond the patient’s initial test was considered in cost assumptions.

2. NON-SURGICAL TREATMENT COSTS (PAP AND ORAL APPLIANCES)

- A. All patients diagnosed with OSA were assumed to initiate and maintain treatment. Based on Frost & Sullivan survey findings, 69% of diagnosed OSA patients were assumed to be using a CPAP/AutoPAP machine (E0601) and 23% using a Bilevel PAP machine (average of E0470/E0471/E0472). Patients were assumed to receive one machine the same year of diagnosis and a new machine every 7.5 years afterward. These assumptions were applied to the number of diagnosed OSA patients to calculate the number of PAP machines sold each year. Pricing for Medicare patients was calculated by multiplying the national average as of January 2015 for the corresponding DMEPOS code for a monthly rental by 13 months, after which the device is assumed to be sold per CMS policy. To calculate prices paid by private insurers, Frost & Sullivan added a 25% premium to Medicare fees to develop private insurance fee rates based on 2014 research by the Commonwealth Fund. These PAP machine prices were multiplied by the number of patients with the respective insurance type by the corresponding price to calculate PAP machine costs.
- B. Recognizing that the accessories used with PAP machines are highly variable, each patient with a PAP machine was conservatively assumed to use the following accessories every six months: 1 Mask: A7030/ A7034/ A7044/ A7027 (Averaged) + 1 Headgear Set (A7035) + 1 Tubing Set (A7037) + 1 Filter (A7038). Prices and costs for accessories were calculated in the same way as for PAP machines themselves.
- C. Frost & Sullivan results indicated 6% of the diagnosed OSA population used a custom oral appliance (E0486). The products may be used as an alternative or an adjunct to PAP therapy. Costs for the products are highly variable with a significant portion of them paid in cash or with high deductibles. Frost & Sullivan developed an estimated price for the Medicare and non-Medicare populations based on research done in the oral appliance market in 2015. The products were assumed to have a lifespan of seven years. The number of oral appliances was calculated by multiplying the percentage penetration of the devices and product lifespan value by the number of diagnosed OSA patients. This number was then multiplied by the number of diagnosed OSA patients split by insurance type and corresponding price to calculate total cost.

3. SURGICAL TREATMENT COSTS

Sum of costs calculated for each of the following surgeries using the following formula:

(Total number of procedures performed in 2015) X (% Patients receiving procedure estimated to be suffering from OSA) X (Average total cost of procedure assuming a weighted payor mix)

- Nasal Reconstruction or Polyp Removal
- UPPP (Standard or Laser Assisted)
- Maxillomandibular/Genioglossus/Hyoid Advancement
- Temperature-controlled RF Tongue Base Reduction/Palatoplasty (Somnoplasty, Coblation)
- Pillar Procedure
- Sclerotherapy
- Tracheotomy for OSA
- Bariatric Surgery
- Tonsillectomy/Adenoidectomy
- Hypoglossal Nerve Stimulation

Note that in some procedures, treatment of OSA may not have been the primary indication, but the percentage used still reflects the prevalence of the condition in that population.

ENDNOTES

1. "2015 Pocket Guide to Large Truck and Bus Statistics." Federal Motor Carrier Safety Administration U.S. Department of Transportation. National Transportation Library, April 2015.
2. "Alcohol and Sleep - Alcohol Alert No. 41-1998." National Institute on Alcohol Abuse and Alcoholism. U.S. Department of Health and Human Services, Oct. 2000.
3. American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. *Sleep*. Aug 1 1999; 22(5):667-689.
4. Aurora, RN, NM. Punjabi. "Sleep Apnea and Metabolic Dysfunction: Cause or Co-Relation?" *Sleep Medicine Clinics (2007)*: National Center for Biotechnology Information. U.S. National Library of Medicine.
5. Barnes, C, and David Wagner. "Changing to Daylight Saving Time Cuts Into Sleep and Increases Workplace Injuries." American Psychological Association. *Journal of Applied Psychology*, 2009.
6. Berger, MD FCCP, Mark B., Wendy Sullivan, RN, Ross Owen, MPA, Charlotte Wu, MS, Precision Pulmonary Diagnostics, Inc., Schneider National, Inc., and Definity Health Corp. "A Corporate Driven Sleep Apnea Detection and Treatment Program: Results and Challenges." *Sleep Apnea Detection and Disordered Breathing Treatment Program*. CHEST Journal, 2006.
7. Centers for Disease Control and Prevention, National Center for Health Statistics. Underlying Cause of Death 1999-2013 on CDC WONDER Online Database, released 2015. Data are from the Multiple Cause of Death Files, 1999-2013, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program: <http://wonder.cdc.gov/ucd-icd10.html>.
8. Centers for Disease Control and Prevention. National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2014. Atlanta, Ga. US Department of Health and Human Services; 2014.
9. "Collision of Union Pacific Railroad Freight Train with BNSF Railway Freight Train Near Chaffee, Missouri, May 25, 2013." Accident Report. Ed. Christopher Hart, Robert Sumwalk, Mark Rosekind, and Earl Weener. National Transportation Safety Board, 25 March 2013. Web. 5 Jan. 2016.
10. Ejaz, SM, IS Khawaja, S. Bhatia, and TD Hurwitz. "Obstructive Sleep Apnea and Depression: A Review." *Innovation Clinical Neuroscience (2011)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
11. Heidenriech, PA, Trogdon JG, Khavjou OA, Butler J, Dracup K, Ezekowitz MD, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*. 2011; 123 (8):933-44.
12. Hirsch Allen, AJ, N. Bansback, and NT Ayas. "The Effect of OSA on Work Disability and Work-related Injuries." *CHEST (2015)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
13. Isidoro, SI, A. Salvasaggio, LO Blue A, S. Romano, O. Marrone, and G. Insalaco. "Effect of Obstructive Sleep Apnea Diagnosis on Health Related Quality of Life." *Health Quality of Life Outcomes (2015)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
14. Ko PR, Kientz JA, Choe EK, Kay M, Landis CA, Watson NF. Consumer sleep technologies: a review of the landscape. *J Clin Sleep Med* 2015; 11(12):1455-1461.
15. Lando, J, Marshall Williams S, Sturgis S, et al. A logic model for the integration of mental health into chronic disease prevention and health promotion. *Prev Chronic Dis*. 2006 April; 3 (2):A61.
16. Levy, P, MR Bonsignore, and J Eckel. "Sleep, sleep-disordered breathing and metabolic consequences." *European Respiratory Journal (2009)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
17. Lin, YN, QY Li, and XJ Zhang. "Interaction between Smoking and Obstructive Sleep Apnea: Not Just Participants." *Chinese Medical Journal (2012)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
18. Lu, B., R. Budhiraja, and S. Parthasarathy. "Sedating Medications and Undiagnosed Obstructive Sleep Apnea: Physician Determinants and Patient Consequences." *Journal of Clinical Sleep Medicine (2005)*. National Center for Biotechnology Information. U.S. National Library of Medicine.
19. Lutsey, P, R. McClelland, D. Duprez, S. Shea, E. Shahar, M. Nagayoshi, M. Budoff, J. Kaufman, and S. Redline. "Objectively Measured Sleep Characteristics and Prevalence of Coronary Artery Calcification: The Multi-Ethnic Study of Atherosclerosis Sleep Study." *Thorax (2015)*.

20. Marin, JM, A. Agusti, I. Villar, M Forner, D. Nieto, SJ. Carrizo, F. Barbe, E. Vicente, Y. Wei, FJ. Nieto, S. Jelic. "Association between treated and untreated obstructive sleep apnea and risk of hypertension." *JAMA* (2012): National Center for Biotechnology Information. U.S. National Library of Medicine.
21. Marin, JM, SJ. Carrizo, E. Vicente, AG. Agusti. "Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study." *Lancet* (2005): National Center for Biotechnology Information. U.S. National Library of Medicine.
22. Messlier, N, F Gagnadoux, P Giraud, C Person, H Oukssel, T Urban, and JL Racineux. "Impaired glucose-insulin metabolism in males with obstructive sleep apnoea syndrome." *European Respiratory Journal* (2003). National Center for Biotechnology Information. U.S. National Library of Medicine.
23. Mozzafarian, D, Benjamin EJ, Go AS, et al. Heart Disease and Stroke Statistics-2015 Update: a report from the American Heart Association. *Circulation*. 2015;e29-322.
24. Mulgrew, AT, G. Nasvadi, A. Butt, R. Cheema, N. Fox, JA Fleetham, P. Cooper, and NT Ayas. "Risk and Severity of Motor Vehicle Crashes in Patients with Obstructive Sleep Apnoea/hypopnoea." *Thorax* (2008). National Center for Biotechnology Information. U.S. National Library of Medicine.
25. Nwankwo, T, Yoon SS, Burt V, Gu Q. Hypertension among adults in the US: National Health and Nutrition Examination Survey, 2011-2012. NCHS Data Brief, No. 133. Hyattsville, Md.: National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, 2013.
26. Omachi, TA, DM Claman, PD Blanc, and MD Eisner. "Obstructive Sleep Apnea: A Risk Factor for Work Disability." *Sleep* (2009). National Center for Biotechnology Information. U.S. National Library of Medicine.
27. Parish, JM, and PJ Lyng. "Quality of Life in Bed Partners of Patients with Obstructive Sleep Apnea or Hypopnea after Treatment with Continuous Positive Airway Pressure." *CHEST* (2003). National Center for Biotechnology Information. U.S. National Library of Medicine.
28. Peppard, PE, T Young, JH Barnet, M Palta, EW Hagen, and KM Hla. "Increased Prevalence of Sleep-disordered Breathing in Adults." *American Journal of Epidemiology* (2013): National Center for Biotechnology Information. U.S. National Library of Medicine.
29. Peppard, PE, T Young, M Palta, and J Skatrud. "Prospective study of the association between sleep-disordered breathing and hypertension." *New England Journal of Medicine* (2000): National Center for Biotechnology Information. U.S. National Library of Medicine.
30. Potts, KJ, DT Butterfield, P Sims, M Henderson, and CB Shames. "Cost Savings Associated with an Education Campaign on the Diagnosis and Management of Sleep-disordered Breathing: A Retrospective, Claims-based US Study." *Population Health Magazine* (Feb. 2013): National Center for Biotechnology Information. U.S. National Library of Medicine.
31. Punjabi, N. "The Epidemiology of Adult Obstructive Sleep Apnea." *American Thoracic Society* (2008): National Center for Biotechnology Information. U.S. National Library of Medicine.
32. "Respiratory Diseases." 2020 Topics & Objectives. [HealthyPeople.gov](https://www.healthypeople.gov).
33. Tefft, Brian C. "Prevalence of Motor Vehicle Crashes Involving Drowsy Drivers, United States, 2009-2013." AAA Foundation for Traffic Safety, (Nov. 2014).
34. Teodorescu, M, DA Polomis, SV Hall, MC Teodorescu, RE Gangnon, AG Peterson, A Xie, CA Sorkness, and NN Jarjour. "Association of obstructive sleep apnea risk with asthma control in adults." *CHEST* (2010). National Center for Biotechnology Information. U.S. National Library of Medicine.
35. The World Health Organization (WHO). The world health report 2004: Changing history. Annex Table 3: Burden of disease in DALYs by cause, sex, and mortality stratum in WHO regions, Estimates for 2002; A126-A127. Geneva: WHO; (2004).

Auckland
Bahrain
Bangkok
Beijing
Bengaluru
Buenos Aires
Cape Town
Chennai
Dammam
Delhi
Detroit
Dubai
Frankfurt
Herzliya
Houston
Irvine
Iskander Malaysia/Johor Bahru
Istanbul
Jakarta
Kolkata
Kotte Colombo
Kuala Lumpur
London
Manhattan

Miami
Milan
Moscow
Mountain View
Mumbai
Oxford
Paris
Pune
Rockville Centre
San Antonio
São Paulo
Seoul
Shanghai
Shenzhen
Singapore
Sydney
Taipei
Tokyo
Toronto
Valbonne
Warsaw



SILICON VALLEY

331 E. Evelyn Ave., Suite 100
Mountain View, CA 94041
Tel 650.475.4500
Fax 650.475.1570

SAN ANTONIO

7550 West Interstate 10,
Suite 400
San Antonio, TX 78229
Tel 210.348.1000
Fax 210.348.1003

LONDON

4 Grosvenor Gardens
London SW1W 0DH
Tel +44 (0)20 7343 8383
Fax +44 (0)20 7730 3343

877.GoFrost
myfrost@frost.com
www.frost.com

Frost & Sullivan, the Growth Partnership Company, works in collaboration with clients to leverage visionary innovation that addresses the global challenges and related growth opportunities that will make or break today's market participants. For more than 50 years, we have been developing growth strategies for the Global 1000, emerging businesses, the public sector and the investment community. Is your organization prepared for the next profound wave of industry convergence, disruptive technologies, increasing competitive intensity, Mega Trends, breakthrough best practices, changing customer dynamics and emerging economies?