Home Sleep Apnea Testing
When, Why, How

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Objectives

• Understand the epidemiology and cost associated with untreated OSA
• Awareness of evaluation methods for screening and diagnosing sleep apnea - role of HSAT
• Understand treatment options for sleep apnea
• Understand the goals of treating sleep apnea
Epidemiology

U.S. Adult Population
245.2 M

12%

Prevalence OSA (AHI>5)
29.4 M

80% 20%

Undiagnosed
23.5 M

Diagnosed
5.9 M

85% 10% 5% 100%

CPAP
5 M

Oral Appliances
0.6 M

Surgery
0.3 M

Lifestyle
5.9 M


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Cost Burden of OSA in the Undiagnosed vs. Diagnosis & Treatment Costs

<table>
<thead>
<tr>
<th></th>
<th>Undiagnosed</th>
<th>Diagnosed</th>
</tr>
</thead>
<tbody>
<tr>
<td># People with OSA</td>
<td>23,500,000</td>
<td>5,900,000</td>
</tr>
<tr>
<td>Cost of Undiagnosed OSA ($US Bil)</td>
<td></td>
<td>Cost of Diagnosed OSA ($US Bil)</td>
</tr>
<tr>
<td>Comorbidities &amp; Mental Health</td>
<td>$30.0</td>
<td>Diagnosis, Testing and Follow Up</td>
</tr>
<tr>
<td>Motor Vehicle Accidents</td>
<td>$26.2</td>
<td>Non-surgical Treatment</td>
</tr>
<tr>
<td>Workplace Accidents</td>
<td>$6.5</td>
<td>Surgical Treatment</td>
</tr>
<tr>
<td>Lost Productivity</td>
<td>$86.9</td>
<td></td>
</tr>
<tr>
<td><strong>Total Costs ($US Bil)</strong></td>
<td><strong>$149.6</strong></td>
<td><strong>$12.4</strong></td>
</tr>
<tr>
<td>Cost per Person</td>
<td>$6,336</td>
<td>$2,105</td>
</tr>
</tbody>
</table>

Comorbidities & Mental Health

Economic Cost\(^1\): $30 B

- Diabetes, stroke, heart disease, and hypertension have direct costs associated with medical expenses, hospital inpatient visits, medication use and mortality rates.

- Mental health can be more subjective including cognitive function, quality of life, mood, depression, energy levels, substance abuse and interpersonal relationships.

<table>
<thead>
<tr>
<th>Comorbidity Cost Factors</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence of Comorbidity</td>
<td>A</td>
</tr>
<tr>
<td>Total National Cost Burden for Comorbidity</td>
<td>B</td>
</tr>
<tr>
<td>Total Cost of Comorbidity Per Person</td>
<td>C = B / A</td>
</tr>
<tr>
<td>Number of Individuals with Undiagnosed OSA</td>
<td>D</td>
</tr>
<tr>
<td>Prevalence Percentage of Comorbidity in Individuals with OSA</td>
<td>E</td>
</tr>
<tr>
<td>Total Number of Individuals with Undiagnosed OSA and the Comorbidity</td>
<td>F = D x E</td>
</tr>
<tr>
<td>Percentage of Individuals with the Comorbidity Who Show Improvement with OSA Treatment</td>
<td>G = E x F</td>
</tr>
</tbody>
</table>

Source: \(^1\)Primary research with experts, secondary clinical research, U.S. Census (2014), Peppard "Increased Prevalence of Sleep-disordered Breathing in Adults." American Journal of Epidemiology (2013), Frost & Sullivan Patient Survey

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Motor Vehicle Accidents

Economic Cost\(^1\): $26.2 B

- According to AAA\(^2\), drowsy driving causes nearly 29% or 328,000 crashes each year
  - 109,000 injuries & 6,400 fatalities
- Commercial drivers treated on CPAP had a 73% reduction in preventable driving accidents. Annual cost savings for trucking company\(^3\):
  - 1,000 employees: $47.8M
  - 11,000 employees: $8.1B

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 x 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) x D |
| Total Cost of Non-reported Non-commercial Accidents Due to Individuals with Undiagnosed OSA | I = 10% x H |
| Total Cost of Motor Vehicle Accidents Where Undiagnosed OSA a Contributing Factor | J = E + H + I |


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Workplace Accidents

- There was an increase in accident rates on days following Daylight Saving Time, “Sleepy Monday”, when just 40 minutes of sleep was lost:
  - 5.7% spike in workplace injury
  - 67.6% increase in days of work lost due to sustained injuries

- Treatment cost savings include reduced lost wages and absenteeism, lower associated medical expenses and better quality of life

Economic Cost\(^1\): $6.5B

Source: \(^1\)Primary research with experts, secondary clinical research, U.S. Census (2014), Peppard "Increased Prevalence of Sleep-disordered Breathing in Adults." American Journal of Epidemiology (2013), Frost & Sullivan Patient Survey

\(^2\) Barnes “"Changing to Daylight Saving Time Cuts Into Sleep and Increases Workplace Injuries.\)” (2009)
• Reduced sleep can result in: Absenteeism, underperformance, behavioral problems, “cyberloafing”, poor decision making, decreased productivity, and the degree of likelihood that an individual will help a fellow colleague.

• Treatment cost savings can result in not only economic productivity, but also improved workplace behavior.

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**Economic Cost**: $86.9 B

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**Lost Productivity**

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**Economic Cost Factors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of Individuals with OSA Employed</td>
<td>A</td>
</tr>
<tr>
<td>Number of Individuals with Undiagnosed OSA</td>
<td>B</td>
</tr>
<tr>
<td>Total Number of Individuals with Undiagnosed OSA Employed</td>
<td>C = A x B</td>
</tr>
<tr>
<td>Percentage of U.S. Workers Who are Hourly</td>
<td>D</td>
</tr>
<tr>
<td>Percentage of U.S. Workers Who are Salaried</td>
<td>E</td>
</tr>
<tr>
<td>Total Number of Individuals with Undiagnosed OSA Employed as Hourly Workers</td>
<td>F = D x C</td>
</tr>
<tr>
<td>Total Number of Individuals with Undiagnosed OSA Employed as Salaried Workers</td>
<td>G = E x C</td>
</tr>
<tr>
<td>Average Number of Absences from Work per Year Due to OSA</td>
<td>H</td>
</tr>
<tr>
<td>Average Hourly Pay for Hourly Workers</td>
<td>I</td>
</tr>
<tr>
<td>Average Annual Salary for Salaried Workers</td>
<td>J</td>
</tr>
<tr>
<td>Costs Due to Undiagnosed OSA-related Absences Among Hourly Workers</td>
<td>K = ((B x I) x H i x F)</td>
</tr>
<tr>
<td>Costs Due to Undiagnosed OSA-related Absences Among Salaried Workers</td>
<td>L = ((l/246) x H i x G)</td>
</tr>
<tr>
<td>Total Costs Due to Undiagnosed OSA-related Absences Among All Workers</td>
<td>M = K + L</td>
</tr>
<tr>
<td>Percentage of Workday Considered Unproductive by OSA Patients Due to OSA Symptoms</td>
<td>N</td>
</tr>
<tr>
<td>Costs Due to Unproductive Work Time Among Hourly Workers with Undiagnosed OSA</td>
<td>Q = ((N x I) x 35 hrs/wk x 50 wks/yr) x F</td>
</tr>
<tr>
<td>Costs Due to Unproductive Work Time Among Salaried Workers with Undiagnosed OSA</td>
<td>P = (N x I) x G</td>
</tr>
<tr>
<td>Total Costs Due to Unproductive Work Time Among All Workers with Undiagnosed OSA</td>
<td>Q = O + P</td>
</tr>
<tr>
<td>Total Cost of Lost Productivity Due to Undiagnosed OSA</td>
<td>R = M + Q</td>
</tr>
</tbody>
</table>

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*Note: This applies to the United States only*
Benefits of Treatment: The “Triple Aim”

Beyond economics and cost savings, imagine what the U.S. would be like if all 29.4 million people with OSA received treatment...

**Payors/ Employers**
- Reduces costs long-term
  - Increases productivity
- Lowers accident rates and liability costs

**Patients**
- Improves health and life expectancy
  - Increases productivity
- Increases quality of life
  - Improves relationships

**Providers**
- Aligns with population health incentives
- Improved outcomes increases profit in a value-based healthcare system
  - Lowers healthcare utilization and reduces admissions
# Barriers to Diagnosis & Treatment

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

*Source: Primary and secondary research*
WHAT IS SLEEP APNEA?
Example of OSA

SIGNS, SYMPTOMS, AND ASSOCIATED CONDITIONS
Symptoms of OSA

- Witnessed apneas
- Snoring, Bed partner leaving bedroom because of snoring
- Gasping/choking at night
- Excessive daytime sleepiness not explained by other factors
- Non-refreshing sleep
- Insomnia
- Nocturia
- Morning headache
- Decreased concentration
- Memory loss
- Decreased libido
- Irritability
Associated Airway Findings

- Recessed chin or small jaw
- Mallampati score of 3 or 4 (measures airway crowding)
- Tonsilar hypertrophy or lateral peritonsilar narrowing
- Macroglossia
- Enlarged or elongated uvula
- High arched or narrow hard palate
- Nasal abnormalities (deviated septum, polyps)
- Large neck circumference
  - $\geq 17$ inches in males
  - $\geq 16$ inches in females
Mallampati Scoring

- Modified version combines Class III and IV into a single class.
Conditions Associated with OSA

- Obesity, weight gain
- Congestive heart failure
- Atrial fibrillation
- HTN, especially when refractory to treatment
- Type 2 Diabetes
- Nocturnal dysrhythmia

- Stroke, MI
- Pulmonary HTN
- Insomnia
- Anxiety
- Depression
- Fatigue
- Hypersomnia
Screening
Screening for OSA: The STOP Questionnaire

– **S**noring?
– **T**iredness, fatigue, or excessive daytime sleepiness?
– **O**bserved apneas?
– **P**ressure (high blood pressure or pre-hypertension)?

• Referral recommended if 2+ affirmative responses to STOP
Other screening

- **BANG**
  - **BMI**: Obese or greater
  - **Age**: post-menopausal, older age
  - **Neck circumference**: ≥17 inches/Males; ≥16 inches/Females
  - **Gender**: Males>Females

- Referral recommended if 3+ affirmative responses to STOP-BANG
Diagnosis
The Sleep Testing Landscape

- Traditional Polysomnography
  - Diagnostic, the ‘gold standard’
  - Therapeutic (CPAP, Bipap, ASV)
  - Split night to institute treatment
  - Office-based study is essentially the above
  - Requires skilled scoring and interpretation
  - Adjustments can be made for faulty equipment (low ‘redo’ rate)
  - Expensive, occasionally long wait times
- Home sleep test / Portable Monitoring
- AutoCPAP
  - CPAP device that self-adjusts pressure
  - Often used to titrate, but I often prescribe this, adjust range
What is Portable Monitoring?

- Term which encompasses many things
  - Oximetry (SaO2)
  - SaO2 + Airflow (AF)
  - SaO2 + Airflow + Effort (EF) (now the minimum requisite)
  - SaO2 + Airflow + Effort (EF) + ECG
  - SaO2 + Airflow + Effort (EF) + ECG + Body position (BP)
  - SaO2 + Airflow + Effort (EF) + ECG + BP + light sensor
  - Auto-titrating CPAP
- Clinical evaluations using PM must be supervised by a practitioner with sleep medicine board certification or eligibility (AASM)
  - Understand the differential dx, sources of error, place in context
How did we get here?

- **1994**: ASA released paper in which they demonstrated usage in > 6000 subjects
- **2000**: ACCP conference meta-analysis & review
- **2004**: Evidence-based review and executive review from AASM, ACCP, ATS. CMS re-evaluates use
- **2005**: **CMS concludes evidence at that time not adequate**
- **2006**: AASM convenes PM taskforce
- **2007**: AASM PM taskforce publishes guidelines
  - CMS releases 2 AHRQ Evidence reviews!
- **2008**: CMS decides PM is adequate to determine OSA diagnosis to provide CPAP
So who qualifies for Portable Monitoring?

- **Who does NOT:**
  - Comorbidities
    - Congestive Heart Failure
    - COPD
    - Hypoventilation
    - Prior surgery for Sleep apnea
    - Other severe systemic illnesses
  - Insurance issues

- **Who Does?**
  - All else?
  - Cannot go to PSG due to immobility, safety, or critical illness
  - Social issues?
Centers for Medicare and Medicaid (CMS) Guidelines for Home Sleep Tests
Will pay for Types I, II, III and IV Studies

* Note CMS Type I-IV studies are different from AASM Type I-IV studies
Type I Studies

- Attended
- EEG
- EOG
- Heart Rate
- Chin EMG
- Limb EMG
- Respiratory Effort at Thorax and Abdomen
- Air Flow
- Pulse Oximetry
Type II
Unattended with minimum 7 Channels
Must Include:

- EEG
- EOG
- Heart rate
- EMG
- Airflow
- Respiratory Effort
- Oxygen Saturation
Type III
Unattended with minimum 4 Channels
Must Include:

- 2 Respiratory/Flow
- Heart rate
- Oxygen Saturation
Type IV
Unattended with minimum 3 Channels
Must include channels that allow
direct calculation of AHI or RDI
CMS will also allow studies done with
PAT (Peripheral Arterial Tone) device
Most HST Devices Rely Upon 3 Signals to Diagnose OSA

- Nasal/Oral Airflow
- Respiratory Effort
- Oximetry
Other Channels Commonly Added:
Pulse, Position, TST, SNORING
Home Sleep Test

Advantages:

• Patient can sleep at home
• Good for immobile, reluctant patients
• Financially attractive to patients and insurers
Home Sleep Test
Disadvantages:

• May Underestimate OSA Severity
• 3-18% Failure rate. Artifact
• Not suitable for central apnea, significant CHF or COPD, morbid obesity
• Miss PLMs, RBD, Seizures
Nocturnal Polysomnography

- Patient undergoes a diagnostic sleep study to assess for the presence of sleep apnea.
Apnea-Hypopnea Index (AHI)

Measures the severity of sleep apnea based on the number of times the person either has an apnea or hypopnea during a nocturnal polysomnography.

- Normal score: <5 events per hour
- Mild Sleep Apnea: 5 to 14 events per hour
- Moderate Sleep Apnea: 15 to 30 events per hour
- Severe Sleep Apnea: 30+ events per hour
Treatment Options
Treatment Options

• **Behavioral**: Exercise and substantial weight loss

• **Positional Aversion Therapy**
  – Tennis ball t-shirt
  – Only for those with apneas while on back
  – Poor adherence/long term efficacy

• **Oral Appliances**
  – Shift jaw forward to keep airway open
  – Only indicated for mild-moderate OSA
  – Contraindicated if poor teeth or TMJ
  – Retest for efficacy recommended
What is the role of mandibular advancement devices?

- Decrease airway collapsibility and enlarge upper airway
  - Requires adequate dentition, may exacerbate TMJ
  - Refer to experienced dentist (sleep dentistry accreditation)

- Less effective than CPAP for normalizing the AHI
  - Mild or moderate OSA: May be reasonable initial therapy
  - Severe OSA: Not recommended as initial therapy
  - Patients may accept better than CPAP

- Follow-up sleep study needed to document adequacy
Surgical Treatment Options

- **Upper Airway Procedures**
  - Tonsillectomy/Adenoidectomy
  - Tracheostomy
  - Uvulopalatopharyngoplasty (UPPP)
    - With or without tonsillectomy
  - Maxillo-Mandibular Advancement (MMA)
  - Multilevel or Stepwise Surgery (combined, staged procedures)
  - Others

- **Bariatric surgery**
  - Risk of surgical complications, pain, infection, long healing time
  - Must have repeat sleep study: poor rate of complete cure
What is the role of surgical intervention?

- **Uvulopalatopharyngoplasty (UPPP)**
  - Small reduction in symptoms
  - Fewer than half of patients have reduction in severity

- **Tonsillectomy, nasal septoplasty**
  - Increase CPAP tolerability + reduce snoring (not cure)

- **Maxillomandibular advancement**
  - Invasive procedure with prolonged postop recovery
  - Cure rate >90%, particularly in nonobese with retrognathia

- **Tracheostomy**
  - Cures OSA
  - Can be used in life-threatening situations
Positive Airway Pressure Therapy

– Most reliable and reversible option for OSA treatment

– Most machines have the option for adjustable humidification and pressure ramp

– Adjustment phase most challenging for patients
Treatment Options

• Positive Airway Pressure Therapy
  – **Auto-Titrating**
    • Automatically adjusts pressures within set range to keep airway open and stop snoring
  – **Bi-level**
    • One pressure for inhalation
    • A lower pressure for exhalation
    • Usually for higher pressures
  – **Continuous**
    • Single pressure throughout the course of therapy use
PAP Therapy Mask Types

- Nasal Mask
PAP Therapy Mask Types

Over nose and mouth only
- Full Face Masks

Over entire face
OSA Treatment Goals
Goals of Treating OSA

- More restful sleep with fewer sleep arousals/awakenings
- The need for fewer night-time bathroom breaks
- Less daytime sleepiness, less need for naps
- Better daytime function
- Less or no snoring
- Happy bed-partners
- Improvement/stabilization of comorbid/associated conditions
- Less stress on heart, lungs, brain, and endocrine systems
- Less risk for sleep-related motor vehicle accidents
- Ability to be more involved and active in one’s own life
Can treatment prevent or modify outcomes in other diseases?

CPAP and MAD therapy reduce blood pressure
Degree of adherence correlates with BP response
CPAP therapy may reduce hypertension
Effect of therapy on cardiovascular outcomes unclear
Other diseases may be modified by OSA therapy
  May modestly increase ejection fraction in CHF
  May reduce likelihood of Atrial fibrillation recurrence
How should treatment be monitored?

- Ensure CPAP use during all sleep sessions
- Assess symptom resolution
- Monitor side effects of CPAP
- Assess comorbid conditions associated with OSA
- Monitor remission due to weight loss or surgery
- Monitor remission in those with history drowsy driving
- If relapse occurs, investigate stepwise:
  - Inadequate therapy adherence
  - Problems with CPAP delivery
  - Change in pressure needs
  - Non-OSA sleep factors
What should patients know about the effects of medications and supplemental oxygen?

- Use sedatives and opiates cautiously (can worsen OSA)
- Exogenous testosterone may exacerbate or induce OSA
- Don’t use supplemental oxygen as primary therapy
  - Treats oxyhemoglobin desaturation associated with OSA
  - Little evidence that it reduces symptoms, BP, CV risk
  - Some patients require both CPAP and supplemental oxygen
How should OSA be treated when a patient is admitted to the hospital?

- Patients should use their CPAP or MAD in the hospital
  - Just as they would at home
- Use sedative and opiate medications cautiously
- If moderate sedation used intraoperatively
  - Monitor ventilation by continuous oximetry and continuous capnography
  - Consider CPAP administration during sedation
- Beware untreated OSA in perioperative setting
  - Higher rate cardiopulmonary complications, ICU transfers
When should a sleep specialist be consulted for management?

- Complicated management situations
  - CPAP-intolerance
  - Persistent symptoms despite therapy
  - Multiple sleep disorders
  - Complex sleep-disordered breathing
Anybody figure this out yet?
Questions?