Health and Societal Costs of OSA

Stanford University Sleep Medicine Program

Obstructive sleep apnea syndrome (OSAS)

- OSAS is a common syndrome.
- It has been calculated that prevalence of OSAS is around 8% in industrialized countries with Caucasian majority.
- It is higher in Black and Far East Asian.
- In Far East Asian it has been estimated to be around 15% (Chinese population).

OSAS

- It has been estimated that in the USA about 80% of OSAS were undiagnosed in 2004.
- Based on epidemiologic studies on representative samples of general populations is known that OSAS is responsible for:
  - Driving and industrial accidents
  - Neurocognitive dysfunction and sleepiness
  - Hypertension
  - Stroke
  - Cardiac arrhythmias

OSAS

- It is suspected that OSAS is responsible for:
  - Myocardial Infarction
  - Cardiac Failure
  - But studies have not been population studies only limited cohort
Economic Calculations

- Calculations have looked at OSA as part of sleep disorders or at OSA in isolation
- Cost analysis looked at
  - A) Direct health cost and
  - B) Indirect health cost:

Direct Health Costs

- Inpatient hospital cost
- General practitioner cost
- Specialists
- Other health care providers
- Pharmaceutical
- Pathology
- Diagnostic imaging
- Outpatient aged care
- Unallocated costs

Indirect Cost

**Financial**

- Work related accidents
- Motor vehicle accidents
- Other productivity losses, related to:
  + absenteeism
  + low productivity
  + premature mortality

**Non Financial**

- Non-financial cost derived from loss of healthy life calculated in terms of burden of disease using disability adjusted life year to which a monetary value was assigned using the "value of statistical life" (A critical review of market estimate throughout the world. Harvard University) discounted to calculate the value of a "life year"
### Study of sleep disorders including OSA

- Example: Australia

### Australia

- Study: Analysis of **direct and indirect costs** of sleep disorders in 2004 in a country of 20.1 million people
- Determination of **direct health costs** of 3 sleep disorders:
  - **Obstructive sleep apnea**
  - **Insomnia**
  - Periodic limb movement disorders with and without restless leg syndrome

### Australia: Results in US dollars

- **Very conservative estimate** were made: 3 chronic primary sleep disorders were estimated to only affect **6% of the population**
- **Most common is OSA at 4%**
- Primary insomnia is considered to only affect 1.25% of the population
- Other syndromes affect 1% of the population

### Australia

- **Sources:**
  - Australian Institute of Health and Welfare
  - Australian Bureau of Statistics
  - National database on demographic
- **Calculation of direct costs**
Australia: Results

- Overall cost was $7.49 billion US subdivided in:
  - Direct health cost: $146 million US
  - Indirect Health Cost
    + Work related injuries: $1.95 billion US
    + Motor vehicle accident: $808 million US
    + Other productivity losses: $1.20 billion US
    + Raising alternative taxation revenue $100 million US
    + Net cost of “suffering”: $2.97 billion US

Australia: Conclusion

- With very low estimate, in 2004, the costs independent of cost of suffering, was high: $4.52 billion US
- This represents 0.8% of Australian gross national product and it does not include “cost of suffering”

Sleep 2006; 29:299

USA (State of Washington)

- Study: evaluation of cost data of a cohort of patients the year prior their diagnosis with OSAS
- Cohort Study performed using a cohort from state of Washington (USA)
- Compared with age, gender and body mass index control cohort
- Outcomes:
  A) Estimation from these data of the potential costs of undiagnosed sleep apnea
  B) Relationship between severity of OSA and magnitude of medical cost

Puget Sound Cohort

- Data base: The Group Health Cooperative (GHC) of Puget Sound (mainly Boeing employees) ~100,000 members
- A Chronic Disease Score (CDS) was calculated from the Group pharmacy data-base
- Direct Medical Costs were obtained from the GHC cost/utilization data base
- Cost were adjusted for 1996-97 dollars using the medical care consumer price index for Seattle
Results

• Compared to controls, undiagnosed OSAS in the prior year had:
  – Mean Chronic Disease Score of 3.3 versus 1.1 (mean) and 3 versus 0 (median)
  – Mean annual medical costs were $2720 versus $1380; median:$1380 versus $539

Results

When controlling for differences in age, sex and BMI, there was a relationship between severity of OSAS (AHI) and medical cost up to a “ceiling”

Results

• Based on the 1990 US census and a low estimate of 4% of men and 2% of women with OSAS
• Extrapolation to the US population gives a medical cost burden of $3.4 billion/year attributable to undiagnosed OSAS

Health Care Utilization with OSA

• Manitoba study (1999): Usage of the Manitoba Health database (hospital stays and outpatient visits)
  • All patients diagnosed with OSA with PSG (n=181) during 1 year and investigation of prior health-related services in prior 10 years
• Compared to age, gender and geographically defined control subjects
Manitoba Study

• Results: significantly (p=0.001) higher usage of health services with increasing usage over time
• In Canadian Dollars: physician claims for OSA group: $686,365 versus 356,376 (ie $3972 versus 1969 per subject)
• Faster rate of increase in the 3 years prior to diagnosis: mean annual increase: $240.67 per OSA subject versus 20.41 for controls

Manitoba #2

• Comparison of health care costs 5 years prior and 5 years post OSA treatment (nasal CPAP)
• Usage of same Manitoba province data
• Subjects: (n=342) age 48.2 ± 0.6 y, males, BMI:35.6 ±0.4 kg/m2; AH1:47.1 ± 1.8;
• Controls (gender, age, geographic)

Sleep 2005-1306

Manitoba Study

• Hospitalizations in 10 years prior to OSA dx: 1118 nights (6.2 per patient) versus 676 (3.7 per patient)
• Probability of admission significantly increased in the 3 years before diagnosis
• Combining physician claim and hospitalization cost: OSA = $1,804,365 Controls = $1,032,376

Sleep 1999

Manitoba #2

<table>
<thead>
<tr>
<th></th>
<th>OSA</th>
<th>Controls</th>
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<tbody>
<tr>
<td>MD visits:</td>
<td></td>
<td></td>
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<tr>
<td>1 yr before</td>
<td>9.21 ±0.44</td>
<td>4.04 ±0.16</td>
</tr>
<tr>
<td>5 yrs after</td>
<td>8.18 ±0.41</td>
<td>4.86 ±0.19</td>
</tr>
<tr>
<td>Fees ($/y):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 yr before</td>
<td>372.1 ±24.1</td>
<td>152.69 ±8.0</td>
</tr>
<tr>
<td>5 yrs after</td>
<td>358 ±18</td>
<td>200 ±9.8</td>
</tr>
</tbody>
</table>

Sleep 2005-1306
Manitoba #2

- The difference in physician visits between the 2 groups between year -1 and +5 was significantly reduced to: 1.85 ±0.52 (95% CI 0.82-2.88)
- As far as fees, there was a significant decrease in cost once OSA patients were treated
- But there was still a difference between cases and controls
- Analysis of fee structure shows that there is a progressive increase in treated OSA from year +2 to year +5. ($76.89/year CI:33.28-120.50)
- This increase is related to syndromes known to be complications of OSA: HTA, congestive heart failure, cerebro-vascular accidents, cardiac arrhythmia
- Association of history of ischemic heart disease with OSA at entry was associated with a 500% increase in expenditure despite treatment between year +1 and +5

Israel Study: Gender Difference

- Gender difference in morbidity and total Health Care utilization 5 years prior OSA diagnosis
- Design: subjects covered by Clalit Health Care Services: largest HMO in Israel covering 60% of total Israeli population.
- Investigation of database for 5 years prior OSA diagnostic
- 289 OSA women, 289 OSA men matched for BMI, age, AHI
- 1/1 matched controls for gender, age, geographic area and primary care physician

Israel Study

Costs (US$)/ 5y

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th></th>
<th>Men</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>462.5±75</td>
<td>0.002</td>
<td>441±73</td>
<td>0.001</td>
</tr>
<tr>
<td>OSA</td>
<td>953±13.5</td>
<td>0.0001</td>
<td>793±97</td>
<td>0.003</td>
</tr>
<tr>
<td>Emergency Dept</td>
<td>92±11</td>
<td>0.0001</td>
<td>83±7.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Controls</td>
<td>175±14.8</td>
<td>0.0001</td>
<td>114±9.2</td>
<td>0.003</td>
</tr>
<tr>
<td>OSA</td>
<td>318±18.7</td>
<td>0.0001</td>
<td>156±12.12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Consultation</td>
<td>521±23.7</td>
<td>0.0001</td>
<td>328±18</td>
<td>0.0001</td>
</tr>
<tr>
<td>Controls</td>
<td>394±21</td>
<td>0.0001</td>
<td>217±24</td>
<td>0.0001</td>
</tr>
<tr>
<td>OSA</td>
<td>602±47</td>
<td>0.0001</td>
<td>459±38</td>
<td>0.0001</td>
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</table>
**Israel Study**

- OSA women have 1.78 times higher 5-year health care cost than matched controls
- OSA men have a 1.89 times higher cost
- Women overall have a higher 5-year total cost
- **Women with OSA have a 1.3 higher cost compared to men with OSA**

**Israel Study**

- **Women with OSA were prescribed:**
  - 2 to 3 times more drugs for GE reflux, analgesics, anti-inflammatory, anti-rheumatic products, psycholeptics and psycho-analeptics
  - 2.86 times more vitamins
  - 3.16 times more antidepressants
  - 1.63 times more sedative-hypnotics
  - 1.62 times more anxiolytics
  - **than OSA men**

Sleep 2007-1173

**Israel Study**

- The study confirms the findings of Manitoba study for cost.
- But the treatment of women confirms our US study on UARS: study of 138 pre-menopausal women diagnosed with Upper Airway Resistance Syndrome or low AHI, untreated due to low AHI refusal of treatment by US insurance companies
- Follow-up 5 years later

**California-UARS Study**

- Follow-up at 5 years with initial and F/U PSG
- N=105 women
- No treatment of SDB but
- **Increase in complaint** of daytime fatigue (10 time higher), insomnia (16 times higher) depressive mood (20 times higher)
- **Increase in prescription** of hypnotics from 11.6 to 67.6% of patients; of antidepressant from 3.2% to 25.5% of patients; of stimulant from 0 to 9.3% of patients

Women and SDB

• One conclusion of these 2 studies is that:
• SDB Women have **different clinical presentation than SDB men** and this clinical presentation is not recognized as part of SDB
• In clinical practice, SDB women receive a large amount of hypnotics, antidepressants, anxiolytics, anti-GE reflux drugs before SDB is considered
• This absence of recognition **increase the health and social costs of SDB**

Health Costs: Elderly

• The secondary comorbidities related to OSA in middle-age adults involving the cardio-vascular system are very well known and we have not considered them
• But many of the behavioral costs are often not considered and they may be a larger economic and social burden than ever considered
• One of the clear ignored impact is the health cost to the elderly

Elderly

• Israeli study (Tarasiuk et al 2008) involving the largest HMO in the country and looking at healthcare cost 2 years prior diagnosis in subjects aged 67-89 years (n=158)
• 1:1 age and gender matched controls according to geographic area and primary care physician
• Results: Health care utilization (consultation+ hospitalization+ drug expenses) were 1.9 times higher for undiagnosed OSA patients compared to controls

Elderly

• Multiple regression analysis showed that, after adjusting for age, BMI, and AHI, the two major sources of increased costs were:
  + cardiovascular morbidity  OR=4.1; 95% CI=1.8-9.3
  + usage of psycho-active drugs  OR=3.8, 95% CI=1.5-10.1
National Highway Traffic Safety Report

- Approximately 0.7% of drivers were involved in a driving accident due to drowsiness.

- 39.3% of subjects recognized with OSA have fallen asleep at the wheel, and 31.98% have had an accident.

Vehicle Crash Risk for individuals with OSA

- Review of 40 pertinent studies, majority of studies found a significant increase risk, usually 2 to 3 times increase compared to non-OSA subjects in non-commercial drivers.

- About half of the studies showed statistical increase risk with increase “severity” of OSA (severity is based on AHI and on ESS score).

- One cross-sectional study using a large (10,000) population-based sample of noncommercial drivers found that men that self-report the diagnosis of OSA have an odds ratio of 3.3 (95%CI 2.0-4.9) of also reporting a recent crash.

  J Clin Sleep Med. 2006 193

Treatment of OSA: Comparison with Pre-treatment Status

- Treatment: nasal CPAP
  - 11 studies analyzed, in all studies independent of whether outcome measure was state driving records, self report, or simulator performance improvement in driving performances or reduction in crash rate was noted.
  - One study using state driving record showed that crash rate in drivers using CPAP return to rate of general population.

- Treatment UPPP (Sweden)
  - 3 studies: post surgery, performances in driving simulator as well as self-reported crash rate improved following treatment.

Review of Literature on Commercial Drivers

- Studied effect of OSA on crash risk in commercial driver population compared to controls (17 studies).
  - Results: underlying crash risk for a CMV driver is 0.08 crashes per person per year.
  - Crash risk for a CMV driver with OSA estimated from meta-analysis from these studies is 0.21 (95%CI: 0.1 to 0.46) crashes per person-year.

  (Independent agency review)
Crash-risk in CMV drivers

- Caveat: If as a group, drivers with OSA are at increased risk for a motor-vehicle accident when compared to drivers without the disorder,

  The magnitude of this increased risk cannot be determined with available data.

Children and SDB

- Two Israeli studies using the largest HMO data base (66% of Israeli population)
  - Comparison of utilization of health care resources in the year preceding the diagnosis of OSA
  - 287 children aged 1-18 years consecutively recognized with OSA after PSG
  - Comparison to controls (n=1149, randomly selected)

Children (Study 1)

- Indices of health care utilization 1 year before the PSG study (clinic visits, drug prescription, emergency room visits, hospitalization)
- Children with OSA have a 226% increase in health care utilization in the year preceding diagnosis with more hospital days, drugs, and visits to the emergency department
- Severity (based on AHI) correlates directly to total annual costs and independently to age (beta = 0.19)
- Children up to 5 years of age consumed more health care resources than children over 5 years

Children (Younger than 5 years)

- Case-control study, starting from the first year of life to date of OSAS diagnosis
- Usage of HMO data base (Clalit Health Care Services, the largest health maintenance organization in Israel )
- 156 patients (age range 3-5 yrs) and their pair-matched healthy control subjects, by age, sex, primary care physician, and geographic location
Before 5 years of age

- From the first year of life to date of OSAS diagnosis, children with OSAS had:
  - 40% more (p = 0.048) hospital visits
  - 20% more repeated (two or more) visits (p < 0.0001)
  - Higher consumption of anti-infective and respiratory system drugs (p < 0.0001).
- There was 215% increase (p < 0.0001) in health care utilization in the OSAS group that was due mainly to higher occurrence of respiratory tract morbidity (p < 0.0001).
- Referrals of children with OSAS to otolaryngology surgeons and pediatric pulmonologists were higher from Year 1 (p < 0.0001) to date of OSAS diagnosis, especially in Year 4 (GR, 9.4; 95% CI, 4.2-21.1).

Children and SDB

- Presentation of SDB in pre-pubertal children is mostly behavioral.
- Disrupted nocturnal sleep
- Daytime irritability
- Aggressiveness
- Sleep terrors
- Sleepwalking
- Nocturnal enuresis
- Inattention
- Hyperactivity
- Poor school performances
- Poor feeding
- Difficulty to wake-up

Epidemiologic studies

- The frequency of sleepwalking in the general population is about 2%. Tucson area children survey (Goodwin et al):
  - The number one association with sleepwalking in children is OSA.
- UK representative sample of the general population (Ohayon et al):
  - The most common association with sleepwalking in teenagers and young adults is OSA.
  - Sleepwalking in teenagers is associated with self or other inflicted violence.
  - This can be a tragedy for the family and is a medicolegal problem for the physician.

ADHD and SBB in children

- Taiwan study (Huang et al):
  - 1/3 of pre-pubertal children referred for suspicion of ADHD present with SDB.
- Comparative treatment of ADHD with SDB with methylphenidate (n=27), adenotonsillectomy (n=25) or no treatment (n=14) and normal control (n=20). The surgical group had a ADHD total score on the ADHD rating scale of 21±7 compared to pre-surgery 31.5±7 while it was 24.7±8.45 for the methylphenidate group. The adenotonsillectomy treated group was the only group where at least 2/3 of the “ADHD” children were above the score of 25 considered as a cut-off point for ADHD (Sleep Med. 2006).
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<th>Social costs of OSA in children</th>
<th>Health care: Summary</th>
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</table>
| • There are 18 studies in the pediatric literature that indicate that SDB in children is responsible for **poorer school performances than controls (including inattention and hyperactivity)** and show that treatment of SDB with adenotonsillectomy leads not only to a significant change compared to pre-treatment AHI, but shows that SDB children post-surgery are **not significantly different from normal control groups**. | • Health care and societal costs are high with undiagnosed and untreated OSA and treatment significantly reduces these costs
• SDB is commonly a familial disease and there are risk factors that can be identified very early, often in early childhood
• **Identifications of these risks factors should allow to prevent appearance of OSA with development of a local neuropathy that will renders treatment much more difficult and forces continuous life-long treatment: a heavy financial and social cost** |

<table>
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<th>Conclusion</th>
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| • We know that the size of the pharynx and the development of the naso-maxillary complex and secondary initial positioning of the mandible is **related to the growth of the frontal lobe during fetal life**
• **The positioning and pressure of the pre-frontal region and the angle of the cortex to the brain-stem is responsible for the size of the anterior fossa of the base of skull** | • The floor of the cranium has developed in phylogenetic association with the brain and the face develops in conjunction with the cranial floor and the brain. The naso-maxillary complex is specifically associated with the anterior cranial fossae
• **The posterior boundary of these fossae establishes the boundary for the mid-face** |
Conclusion

• The pharynx relate specifically to the middle fossa. In man the size of the middle fossa determines the horizontal dimension of the pharyngeal space.
• Despite remodeling, we can regularly follow the cranial-facial development of at risk subjects

Conclusion

• Understanding the growth of the face in childhood and following the changes seen in the growth of the naso-maxillary complex and the mandible should allow to follow the development of the upper airway size and evaluate risks associated with impaired growth during childhood
• This type of systematic evaluation will be needed to possibly prevent development of abnormal breathing during sleep and its costs through life.