Second Hand Smoke
Third Hand Smoke

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Learning Objectives

- Define 2nd hand smoke (SHS) and 3rd hand smoke (THS) including their composition
- Present a current update on the health effects of SHS
- Understand the potential harm of THS
- Describe briefly THS exposure to smokeless tobacco and vaping of e-cigarettes
SHS Background

- **1964**: US Surgeon General Report
- **1975**: MN Clean Indoor Air Act
- **1992**: EPA report on ETS and Lung Cancer and other respiratory diseases
- **1999**: California EPA report on Health Effects of ETS
- **2006**: The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General
SHS or Environmental Tobacco Smoke (ETS)?

- Active smoking
- Passive smoking
- SHS or ETS?
  - SHS preferred
  - ETS originated with industry

Mainstream Smoke (MS): The smoke drawn through the mouthpiece of the cigarette when puffs are taken

Sidestream Smoke (SS): The smoke emitted from the smoldering cigarette between puffs

Secondhand Smoke (SHS): Combination of SS and exhaled MS
SHS – Secondhand Smoke

- Type 1A carcinogen
- A few thousand chemical compounds
- 200+ toxic
- 50+ carcinogens (Categories 1, 2)
- Additives and masking agents

- Secondhand smoke causes nearly 34,000 premature deaths from heart disease each year
- Secondhand smoke causes more than 7,300 lung cancer deaths among U.S. nonsmokers each year
- Smoking by women during pregnancy increases the risk for SIDS
- Infants who are exposed to secondhand smoke after birth are also at greater risk for SIDS
- Secondhand smoke can cause serious health problems in children (more sick days, asthma, coughing, respiratory infections, ear infections)

http://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/health_effects/index.htm#heart
SHS – Secondhand Smoke – Overview

- 600,000 deaths annually
- % of deaths worldwide
- 47% among women, 28% in children and 26% in men

Partial bans do not work

- Separate areas do not work
- Enforcement is crucial
- Ashtrays and signage are important aspects

## Composition of 2nd Hand Smoke

<table>
<thead>
<tr>
<th>Mainstream smoke (MS)</th>
<th>• Smoke drawn directly through the end of the cigarette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidestream smoke (SS)</td>
<td>• Smoke that is given off by the smoldering cigarette</td>
</tr>
<tr>
<td></td>
<td>• Generated at lower temp than MS and level of toxic chemicals greater than MS</td>
</tr>
</tbody>
</table>

Passive and active smoker inhales both types
Toxic Chemicals in SHS

- Carbon monoxide
- Cyanide, polycyclic aromatic hydrocarbons
- Radioactive polonium
- Benzo-(a)pyrene,
- Acrolein
- Benzene
- Oxides of nitrogen

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## Estimated Death & Disease from ETS

<table>
<thead>
<tr>
<th>Adults</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung CA</td>
<td>7,000 <strong>deaths</strong></td>
</tr>
<tr>
<td>CHD</td>
<td>34,000 to 62,000 <strong>deaths</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIDS</td>
<td>1,900 to 2,700 <strong>deaths</strong></td>
</tr>
<tr>
<td>O.M.</td>
<td>0.7 to 1.6 <strong>million</strong></td>
</tr>
<tr>
<td>New asthma</td>
<td>8,000 to 26,000 <strong>cases</strong></td>
</tr>
<tr>
<td>↑ asthma</td>
<td>0.4 to 1.0 <strong>million</strong></td>
</tr>
</tbody>
</table>
Some groups have higher exposure to secondhand smoke and its harmful effects

<table>
<thead>
<tr>
<th>Category</th>
<th>Exposure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-11 years</td>
<td>41</td>
</tr>
<tr>
<td>12-19 years</td>
<td>34</td>
</tr>
<tr>
<td>≤20 years</td>
<td>21</td>
</tr>
<tr>
<td>White</td>
<td>22</td>
</tr>
<tr>
<td>Black</td>
<td>47</td>
</tr>
<tr>
<td>Mexican-American</td>
<td>24</td>
</tr>
<tr>
<td>Below poverty level</td>
<td>43</td>
</tr>
<tr>
<td>At/above poverty level</td>
<td>21</td>
</tr>
<tr>
<td>Own</td>
<td>19</td>
</tr>
<tr>
<td>Rent</td>
<td>37</td>
</tr>
</tbody>
</table>


Exposure to secondhand smoke differs among children ages 3-11 by race/ethnicity

- Non-Hispanic black children
- Non-Hispanic white children
- Mexican-American children

*Data come from measuring cotinine, which is a marker of secondhand smoke exposure found in the blood.

Health Effects of SHS

- SHS attributable mortality
- Lung cancer
- Cardiovascular disease
- Otitis media
- Peripheral vascular disease
- Cognitive function
- Osteoporosis
SHS and Lung Cancer

- Lung cancer-first reported in non-smoking wives exposed to SHS from their spouses 1981
  - Hirayama (Japan)
  - Trichopoulous (Greece)

- US EPA published a meta analysis of 31 studies in 1992 classified SHS as a group A carcinogen

  Another meta analysis of 37 studies → Increased lung cancer risk 24% (Hackshaw et al 1997)
Lung Cancer Mortality and Smoking

- Non-smoker wives of non-smoker husbands
- Non-smoker wives of husbands with smoking habits
- Women with smoking habits

Standardized mortality rate for lung cancer/100,000

- Non-smoker Familial passive smoking (-): 8.70
- Non-smoker Familial passive smoking (+): 15.50
- Cigarette smokers: 32.79

Population at enrollment:
- 21,895
- 69,645
- 17,366

Total: 108,906

Passive Smoking in China

• China has over 300 million smokers (1/3 of the world’s total number of smokers)
  50% of males are smokers

• China has 530 million “passive smokers”
  • Ref Yang G. Lancet 2008 Nov. 8:372 (9650)

• China has an epidemic of lung cancer which is rapidly increasing among women even though <5% are active smokers
SHS Attributable Mortality

- In the USA 38,000 deaths annual
- Increased risk of heart disease by 30%
- Increased risk of stroke, cancer, DM2 and pulmonary disease
SHS and Casino Patrons

• 18 nonsmokers with no ETS exposure for several days prior to 4 hour casino visit

• Spot urine before visit and 24 hour urine after visit

• NNAL – metabolite of tobacco specific-carcinogen NNK

• ↑ urine cotinine (P<0.0001) and total NNAL (P=0.0004) from baseline

SHS and Cardiovascular Disease

- Cal/EPA noted an overall excess risk of 20-50% for CHD due to SHS exposure

- Reduction in CHD hospital admissions of smoking ban
  - Helen, Montana, Italy and Scotland
Smoke-Free Ordinances and Heart Attacks

• Helena, MT: Monthly admissions for AMI ↓ 40 → 16 (CI -31.7 to -0.3)
  Sargent, RP.  BMJ 328:977, 2004

• Pueblo & El Paso, CO: ↓ Admissions for AMI in Pueblo 257/100,000 person years → 187 vs. El Paso 119 → 116 (Post to Pre RR 0.73 vs 0.97)
  Bartecchi, C.  Circulation 114:1490, 2006

• Piedmont Region, Italy: Admissions for AMI ↓ 11% 922 → 832 (sex, age-adjusted rate ratio 0.89, CI 0.81-0.98)
  Barone-Adesi, F.  Eur Heart J 27:2468, 2006

• Bowling Green & Kent, OH: 47% ↓ Admissions for CHD 3 years after ordinance
Health Risks of 2\textsuperscript{nd} Hand Smoke

- Passive smoking significantly increased the risk of both chronic otitis media and recurrent otitis media. (O.R. 1.39)
  - Ref. metaanalysis of 24 studies; Zhangy et al
SHS and Middle-ear Disease

• Most consistent with “recurrent” otitis media

• There is a causal association between SHS exposure on otitis media in children
Health Risk of 2nd Hand Smoke

Intermittent Claudication (IC)

• In a Scottish study for 4231 non-smokers, those with cotinine concentrations >2.9 ng/ml compared with those with a cotinine level <0.7 ng/ml were significantly more likely to have IC (O.R. 1.76)

  • Ref: Lu L, et al Heart. 2013, Sept:99(18):1342
Health Risk of 2\textsuperscript{nd} Hand Smoke

• Passive smoking in utero showed inverse relationships between SHS and cognitive function Postnatal SHS exposure was associated with poor academic achievement and neurocognitive performance in older children and adolescents

• SHS also associated with neurodevelopment delay
  • Metaanalysis of 15 articles
Health Risks of SHS

• Of 3,540 cases of colorectal cancer, individuals with past SHS exposure were significantly younger at the time of CRC dx

• Compared to lifelong never smokers
SHS Health Effects in Infant

- Maternal smoking associated with low birth weight of infant
- Increased risk of SIDS
- Increased risk (50%) of lower respiratory infections bronchitis and pneumonia in first year of life increased
- Increased airway bronchospasm $\rightarrow$ asthma
Bone Density and SHS

• In The Danish KRAM study, 15,544 men and women underwent a Bone mineral density exam

• 39.1% had been exposed to passive smoking in adulthood

• BMD was significantly lower in SHS exposed adults who had been exposed for >20 years

  • Ref. Holmberg t et al; Osteoporos Int. 2011 Dec;22(12) 2989
Parents Smoking in their Cars

• In a survey of 795 parents who were interviewed immediately after their children saw their pediatrician, 48% reported smoking occurred with children present and only 12% were advised by the pediatrician to have a smoke-free car

• Ref. Emara Nabi-Burza et el; Pediatrics, 2012 Dec.; 130(6)
Which emits more particulate matter into the air in 30 minutes:

- 2L diesel engine
- 3 smoldering cigarettes
Particulate Matter From Cigarettes vs Diesel Car Exhaust

10 to 15 times increase in mean particulate matter (PM) cigarettes vs diesel exhaust

Invernizzi G. Tob Control 13:219, 2004
U.S. Surgeon General Report 2006

6 Key Findings


2. Secondhand smoke causes disease and premature death in children and adults

3. ↑ risk of SIDS, acute respiratory infections, ear infections and more severe asthma in exposed children

www.surgeongeneral.gov/library/secondhandsmoke
U.S. Surgeon General Report 2006

6 Key Findings

4. Immediate adverse effects on C.V. system in exposed adults and causes heart disease and lung cancer.

5. No risk-free level of exposure.

6. Eliminating smoking indoors protects non-smokers but ventilation and/or separation do not.
Third Hand Smoke: Definition

- The residual smoke contaminants that remains after a cigarette is extinguished
- These contaminants may be deposited on furniture, rugs, drapes, clothing, windows; any object in the vicinity of the extinguished cigarette

3rd hand smoke – ”3 Rs”
Aged tobacco smoke pollutants that “REMAIN” on surfaces after tobacco has been smoked
Are “READMITTED” back into the gas phase
Or “REACT” with oxidants and other compounds in the environment to yield secondary pollutants.
Third Hand Smoke

- Carcinogens
- DNA damage
- Chemical changes
- Exposure in hotels, homes, cars
- Exposure from smokeless tobacco
- Exposure from e-cigarettes
Third Hand Smoke

• In an analysis of mainstream/sidestream smoke by a smoking machine for PAHs, nicotine, cotinine and tobacco specific nitrosamines (carcinogens)

• The majority of these compounds released during smoking in homes deposit on room surfaces

• Exposure to these “carcinogens” through dermal absorption and inhalation of contaminated dust may lead to smoking–related morbidity and mortality
  • Ref. Tobacco control, Shick et al 4/24/13
Third Hand Smoke Carcinogen

• The potent tobacco-specific lung carcinogen NNK (4-methynitrosamine)-1-(3-pyridyl)-1-butanone was identified from surface dust samples from the homes of smokers (33 out of 37) vs only 3 of 19 nonsmoker’s homes

• The potent tobacco-specific lung carcinogen NNK is present on surfaces in most homes occupied by smokers

• Home buyers or renters BEWARE
  • Ref. NTR Thomas, J.L. et al 7/26/13 NTR
Third Hand Smoke and DNA Damage

• THS undergoes chemical transformations during aging period and reacts with indoor nitrous acid to form tobacco specific nitrosamines (TSNAs) including NNA and NNK

• Cell cultures exposed to NNA → increased DNA strand breaks and higher levels of DNA damage
  - Ref: Hang, B et al; Mutagenesis, pp 1-11, 2013
Third Hand Smoke

• SHS undergoes numerous chemical changes after it is released into the air

• After it is absorb to indoor surfaces, it may desorb back into the air and undergo chemical changes

• In an analysis of sidestream and mainstream cigarette smoke generated by a smoking machine, after 60 minutes aging, PAHs, nicotine, cotinine and nitrosamine were measured
Third Hand Smoke Exposure in California Hotels

• Compared with hotels with complete smoking bans, surface nicotine and air 3EP (3-ethynylpyridine) were elevated in both non-smoking and smoking rooms of hotels that allowed smoking.

• Non-smoking Guests staying in hotels without complete smoking bans showed higher levels of finger nicotine and urine cotinine that those staying in hotels with complete bans.

• Ref. Matt GE et al; Tob. Control 3/20/13
Residential Third Hand Smoke Exposure

• Although smoker homes’ dust, surface and air nicotine levels decreased after a change of occupancy, they still showed higher contamination levels than those of non-smoker homes. **This persists up to 2 months!!**

• Non smoker new occupants of smoker homes are exposed to THS polluted surfaces and showed higher finger nicotine content
  • Ref. Matt et al, Tobacco control 9/22/10
Parental Smoking in Cars

- In a pilot study in New Zealand researchers found that mean PM*2.5 concentration in a car where 3 cigarettes were smoked and then extinguished, the PM2.5 concentration did not return to baseline for 40 minutes after the last cigarette was smoked.

  - ref. (Edwards et al, 2006; New Zealand Medical Journal, 119(1244))
  - *Respirable suspended particles <2.5 microns
Residual Tobacco Smoke Pollution in Used Cars for Sale

- Use of a cutpoint for nicotine levels from surface wipe samples correctly identified 82% of smoker cars without smoking bans, 75% of smokers with bans and 100% of nonsmoker’s cars

- Ref. Matt Ge et al Nicotine and Tobacco Research vol 10, no. 9;’ sept. 2008

Invernizzi G. Tob Control 13:219, 2004
Third Hand Smoke Belief of Parents after a Visit With the Pediatrician

- Exit interview data were collected from 1980 parents following a pediatric office visit
- 91% agreed that THS can harm the health of babies and children
- Fathers and parents who smoked > 10 cpd were less likely to agree with this statement
- Parents who advised to have a smoke-free home and car and were referred to a “quitline” were more likely to agree with THS harm
- Pediatricians’ advise to parents to quit smoking or adopt a smoke free home or car were correlated with parental belief that THS harms children
Household Survey THS

- 1,510 parents completed surveys (18.9% smokers)
- 95% of nonsmokers vs 84.1% of smokers agree that second hand SHS harms children
- 65.2% of nonsmokers vs 43.3% of smokers agreed that THS harms children
- Rules prohibiting smoking in the home; 88% of nonsmokers vs 27% of smokers
- Beliefs about the harms of THS are associated with home smoking bans
  - Ref Winickoff et al; Pediatrics, 2009 Jan; 123(1):e74-9
Smokeless Tobacco Nicotine Levels

• Vacuum dust Samples from 6 residences occupied by a ST user, 6 residences occupied by active smokers and 20 tobacco-free residences were analyzed for nicotine levels

• Samples from the residences of ST users had significantly higher levels (21 x as high) of nicotine levels than of residences of tobacco free homes

  • Ref. Whitehead et al NTR 7/24/13
Third Hand Smoke from e-cigarettes

• A Roswell Park team evaluated nicotine levels released from e-cigarettes and deposited on surfaces
• The e-cigarettes were “vaped” with a syringe in an exposure chamber
• There were varying levels of nicotine deposited on glass, floor, walls, windows, wood and metal with the floor and glass windows having the greatest amount
SHS and SHA exposure in Youth

• Data were from the National Youth Tobacco Survey from 2015 to 2018.
  • Sample sizes (overall response rates) were 17,711 (63.4%) in 2015, 20,675 (71.6%) in 2016, 17,872 (68.1%) in 2017, and 20,189 (68.2%) in 2018.
SHS and SHA exposure in Kids

• Between 2015 and 2018, approximately half of US middle school and high school students reported SHS exposure in the preceding 30 days, with a significant downward trend in 2017 and 2018 (2015, 52.6%; 2016, 53.4%; 2017, 50.5%; 2018, 48.7%) (Figure).

• Prevalence of SHA exposure increased from approximately 1 of 4 students between 2015 and 2017 to 1 of 3 students in 2018, with a significant upward trend in 2018 (2015, 25.2%; 2016, 26.5%; 2017, 25.6%; 2018, 33.2%) ( 
Figure. Trends in Prevalence of Secondhand Smoke (SHS) and Secondhand Aerosol (SHA) Exposure in Public Places Among US Middle and High School Students

Whiskers represent 95% CIs for each prevalence estimate. Prevalence estimates and 95% CIs were based on weighted analyses to be representative of the US middle and high school student population. The number of missing cases for SHS and SHA exposure items were, respectively, 809 (4.6%) and 791 (4.5%) in 2015, 1031 (5.0%) and 1063 (5.1%) in 2016, 819 (4.6%) and 811 (4.5%) in 2017, and 1015 (5.0%) and 989 (4.9%) in 2018.

a Significant difference between SHS exposure in 2017 and exposure in 2016.
b Significant difference between SHS exposure in 2018 and exposure in 2015 and 2016.
Summary

• The health risks of second hand smoke exposure include the same smoking-related diseases as active smoking – cardiovascular disease and cancer

• Although few data document the health effects of third hand smoke, exposure to THS contains identical carcinogens as inhaled by the active smoker and it’s more widespread than SHS

• STAY TUNED for future studies
Questions & Discussion