Disclosure

Dr. Suzaynn Schick and Catherine Saucedo have disclosed no financial interest/arrangement or affiliation with any commercial companies who have provided products or services relating to their presentation or commercial support for this continuing medical education activity.
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For Tobacco & Cancer Control
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Today’s Speaker

Suzaynn Schick, PhD

- Assistant Professor, School of Medicine, University of California, San Francisco
Thirdhand Cigarette Smoke: A Persistent Environmental Contaminant

Suzaynn F. Schick, PhD
University of California, San Francisco
Thanks

• Lab Staff
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Indoor Surfaces

SHS

THS
What is Thirdhand cigarette smoke?  
**The 3 R’s**

Chemicals in cigarette smoke that:

- **Remain** on surfaces and in dust
- **Re-emit** back into the gas phase
- **React** with other chemicals in the environment to make new chemicals
Chemical Exposure Routes

- Respiratory
- Ingestion
- Dermal
What is smoke?

- Gases
- Particles and droplets of oils and waxes (Tar)
- 10% of secondhand smoke is tar

Thirdhand Smoke starts with Tar
Remain

• Tar chemicals stick to surfaces before they can be removed by ventilation
  • Walls, carpet, dust, people...

• Tar absorbs into porous materials

• Tar contains nicotine and many toxins and carcinogens
  • Nitrosamines
  • Polycyclic aromatic hydrocarbons

• Persistence increases exposure time
Re-Emit

• Combustion forces tar chemicals (normally solids or liquids) into the air
• Tar cools, condenses and sticks to surfaces
• Once on a surface, each chemical reaches equilibrium
• Fraction in the air depends on the chemical
Acetone  Nicotine  NNK
Acetone  Nicotine  NNK
Acetone  Nicotine  NNK
React

• Where there are chemicals, there are chemical reactions

• Which reactions do we know about?
  – Nicotine + nitrous acid = \textbf{NNK}
    » Carcinogen
  – Nicotine + ozone = \textbf{formaldehyde}
    » Carcinogen
  – Tar + ozone = \textbf{ultrafine particles}
    » Can cause heart and lung disease
Truth Initiative Tobacco Documents Library

An archive of 14 million documents created by tobacco companies about their advertising, manufacturing, marketing, scientific research and political activities, hosted by the UCSF Library and Center for Knowledge Management.
RESERCH PAPER

Philip Morris toxicological experiments with fresh sidestream smoke: more toxic than mainstream smoke

S Schick, S Glantz


RESERCH PAPER

Sidestream cigarette smoke toxicity increases with aging and exposure duration

Suzaynn Schick, Stanton A Glantz


Concentrations of the Carcinogen 4-(MethylNitrosamino)-1-(3-Pyridyl)-1-Butanone in Sidestream Cigarette Smoke Increase after Release into Indoor Air: Results from Unpublished Tobacco Industry Research

Suzaynn F. Schick and Stanton Glantz

Center for Tobacco Control Research and Education and the Lung Biology Center, Department of Medicine, University of California, San Francisco, California
Thirdhand Smoke Studies at Philip Morris

FIGURE 1  EXPERIMENTAL SETUP FOR SMOKE GENERATION
Nicotine persisted in surfaces (after smoking ended)
NNK persisted in surfaces (after smoking ended)
Thirdhand Smoke at Philip Morris

• Remains
  – *Aging decreases concentration of particles and nicotine in air*
  – *Adding carpet and cloth to room increased losses*
  – Chemicals persisted on/in surfaces after 50-110 days of constant ventilation with clean air

• Re-Emits
  – After ventilation with clean air overnight, the air still contained lots of nicotine

• Reacts
  – Nicotine reacts to form NNK
Thirdhand Smoke Studies at UCSF
Secondhand Smoke at UCSF

Smoke from cigarette smoking machine is diluted with filtered air, aged 30 minutes, then delivered to the study participant.
Respiratory exposure
Thirdhand Smoke Emits Particles
Normal particle output

mg/m³ vs. Time

Time:
- 9:30
- 9:45
- 10:00
- 10:15
- 10:30
- 10:45
- 11:00

mg/m³:
- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
Something coming out before start the smoking machine
“Secondary” particles from Thirdhand Smoke

mg/m³

Time

9:30 9:45 10:00 10:15 10:30 10:45 11:00
Secondhand Smoke Generation Mode

Thirdhand Smoke Deposition Mode

Thirdhand Smoke Exposure Mode
Secondhand and Thirdhand Smoke particles differ

![Bar chart showing concentrations of nicotine, cotinine, and NNK in SHS and THS](image-url)

- **Nicotine**
  - SHS: 9,500 ng/m³ air
  - THS: 9,000 ng/m³ air
- **Cotinine**
  - SHS: 1,200 ng/m³ air
  - THS: 1,000 ng/m³ air
- **NNK**
  - SHS: 100 ng/m³ air
  - THS: 50 ng/m³ air
Thirdhand Smoke Emits Volatile Chemicals
Paper exposed to smoke emits volatile chemicals
Respiratory Exposure to Thirdhand Smoke In Human Participants
Study design and sample collection

Day 1
- Pre-exposure
- Exposure (3 hours)
- Post-exposure

Day 2
- Next morning
- Next day

Collection times:
- Urine: Pre, Post, Before Bed, First AM, Next Day
Cotinine is a biomarker of nicotine exposure

- Metabolite of Nicotine
- Biomarker of smoking and exposure to Secondhand Smoke and Thirdhand Smoke
- Half-life of 16 hours
Breathing Thirdhand Smoke increases cotinine
Health effects of Thirdhand Smoke exposure in mice

- Smoke cages (curtain, carpet, cloth swatches inside)
- Mice live in cages for 6 months
- Depilate backs weekly
  - Nair on mice...
- Change cages weekly
- Control mice live in separate room in unsmoked cages
Health effects in mice

- Induces type II diabetes
- Causes hyperactivity
- Speeds up blood clotting
- Slows wound healing/changes skin structure
- Damages liver/elevates blood lipids
- Increases oxidative stress
- Slows growth
Non-obese type II diabetes

- 49% of exposed mice showed these effects
Hyperactivity

First 10 mins  Last 10 mins of 1 Hour

Control

THS
Faster blood clotting

![Graph showing bleeding time comparison between Clean Air and THS with P-value < 0.0002 and sample sizes (8 and 7 respectively).]
Charting the Unknown: Data from Marijuana and E-Cigarettes
Similarities between tobacco and marijuana smoke

• Leaf contains high concentrations of oils and waxes
• Nicotine and THC both survive combustion
• It doesn’t matter what you burn: Combustion creates complex, toxic aerosols
# Toxins in Sidestream

<table>
<thead>
<tr>
<th>Health Effects</th>
<th>Tobacco</th>
<th>Marijuana</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight (mg)</td>
<td>788</td>
<td>769</td>
</tr>
<tr>
<td>puffs</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>tar (mg)</td>
<td>Multiple</td>
<td>24</td>
</tr>
<tr>
<td>CO (mg)</td>
<td>Inhibits respiration</td>
<td>62</td>
</tr>
<tr>
<td>Ammonia (mg)</td>
<td>Irritant</td>
<td>5.6</td>
</tr>
<tr>
<td>Nicotine (mg)</td>
<td>Addictive</td>
<td>5</td>
</tr>
<tr>
<td>NOx (mg)</td>
<td>Inflame lung</td>
<td>1.2</td>
</tr>
<tr>
<td>Formaldehyde (μg)</td>
<td>Carcinogen</td>
<td>886</td>
</tr>
<tr>
<td>Acrolein (μg)</td>
<td>Cardiotoxin</td>
<td>437</td>
</tr>
<tr>
<td>HCN (μg)</td>
<td>Toxin</td>
<td>84</td>
</tr>
<tr>
<td>Benzo (a) pyrene (ng)</td>
<td>Carcinogen</td>
<td>91</td>
</tr>
<tr>
<td>NNK (ng)</td>
<td>Carcinogen</td>
<td>92</td>
</tr>
</tbody>
</table>

Moir et al., 2008
Terpenes, cannabis and particle formation

• Terpenes are odorant, bioactive chemicals found in cannabis, tobacco and e-liquids
  • Limonene, Pinene, Linalool, Myrcene and others
• Secreted by plant glands that make THC
• Used to reduce viscosity of hash oil in vape pens
• React to form ultrafine particles in air
Thirdhand Smoke is a persistent environmental contaminant

• **Remains**
  – Chemicals stick to surfaces
  – Weeks and months of ventilation do not remove Thirdhand Smoke

• **Re-Emits**
  – Nicotine, formaldehyde, acetonitrile, acetone and other volatile chemicals

• **Reacts**
  – Nicotine reacts to form NNK
  – THS reacts to form particles
E-Cigarette Toxins

• THS potential unknown
• Aerosol contains smaller particles
  – Median diameter for cigarettes: 110-340 nm
  – Median diameter for e-cigarettes: 5-50 nm
  – E-cigarette particles evaporate faster
• Nicotine
  – No sidestream but, more spills and leaks
• Flavorings: benzaldehyde (cherry), cinnamonaldehyde ...
Summary I

- 10% of the smoke of every cigarette persists in the environment
- Thirdhand smoke is toxic and carcinogenic
- Thirdhand smoke on surfaces emits constant low levels of particles and chemicals
Summary II

• Breathing thirdhand smoke causes detectable increases in the levels of nicotine in the body
• Thirdhand smoke may have health effects
• Marijuana smoke probably creates THS too
• E-cigarettes probably also create THS
Conclusions

• Living in spaces where people have smoked increases exposure to toxins and carcinogens

• The concentrations are lower, but the exposure is continuous and persistent

• Smoking bans in housing, workplaces, hotels and rental cars will reduce thirdhand smoke exposure
Questions and Answers

• Submit questions via the chat box
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