

Thirdhand Smoke

The Lasting Toxic Legacy of Tobacco Smoke

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<https://thirdhandsmoke.org/>

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Mission: To share **information, resources, and technical support** with California's residents, communities, businesses, health care professionals, and policymakers about the toxic legacy of tobacco smoke residue and to achieve **indoor environments that are 100% free of tobacco smoke toxicants.**



Overview

1. **Thirdhand Smoke (THS)**

Where does it come from? What does it consist of? Where is it?

2. **Measurement of THS**

(surface wipes, dust, air silicone wristbands)

3. **Examples:**

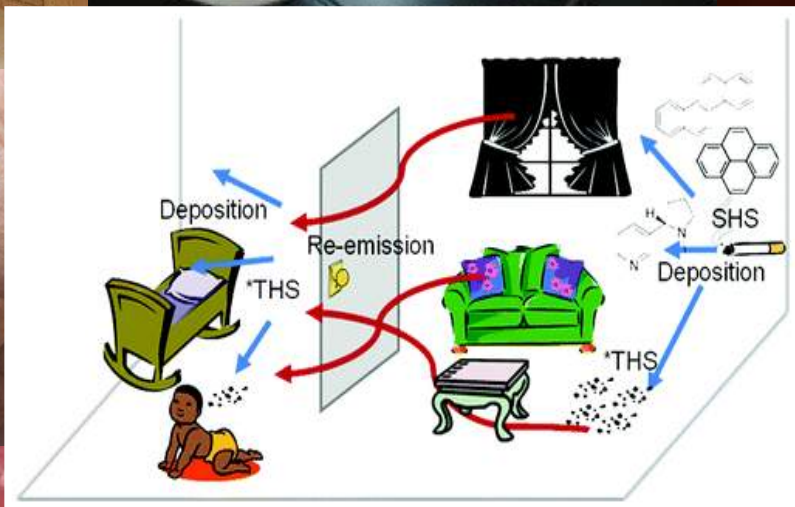
1. Prevalence of THS in Multiunit Housing (MUH) in San Diego
2. Workplace exposure – truck driver

4. **Smoke-free workplaces**

5. **Next steps: thirdhand smoke**

6. **Questions/ Discussion**

1. What is Thirdhand Smoke?



1. What is Thirdhand Smoke?

Comes from Secondhand Smoke (SHS, ETS):

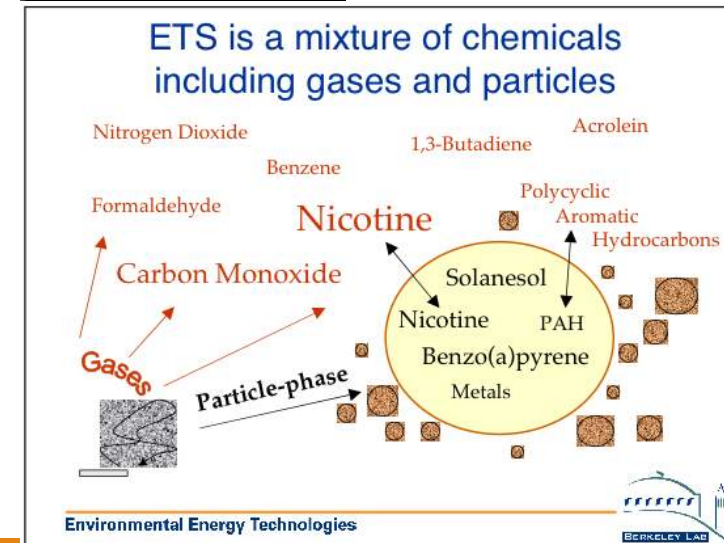
- 15%= exhaled main-stream smoke
- 85%= of side-stream smoke

Side- and main-stream smoke differ

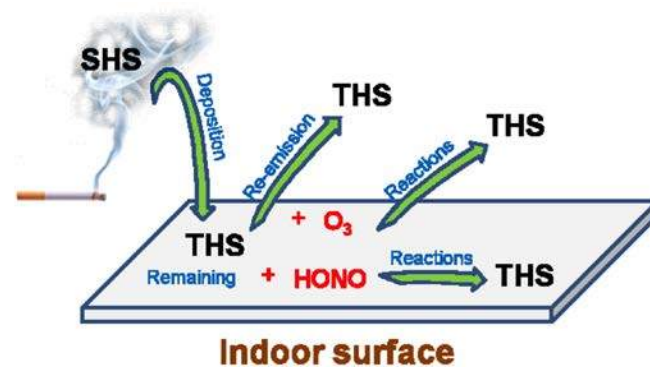
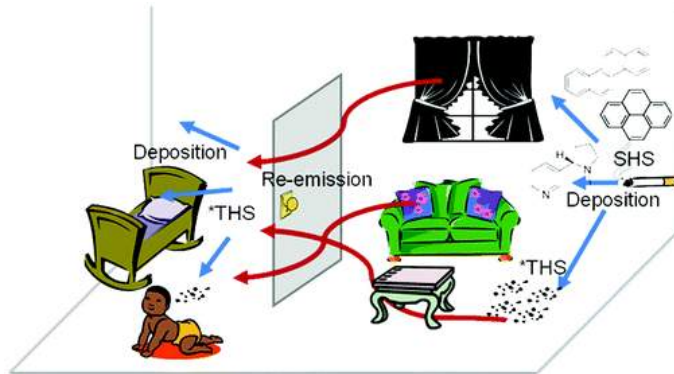
- Tobacco burns at lower temperature, leading to incomplete combustion
- Higher concentrations of toxic gases and particles
- Produces smaller particles that reach and stay in deep lung (sub-micron)

SHS travels throughout a room, home, neighboring apartments, outdoor spaces

Duration depends on air exchanges, ventilation



1. What is Thirdhand Smoke?



Within seconds of lighting a cigarette, chemical processes start that turn SHS into THS

- Gas-phase SHS: adsorb on surfaces and in materials
 - Adsorption – Desorption dynamics
- Particulate-phase SHS: deposit, accumulate
- THS undergoes further chemical reactions:
 - Nicotine plus HONO produces NNK, a potent lung carcinogen

1. What is Thirdhand Smoke?

Toxic Constituents of THS include:

Nicotine, formaldehyde, metals (Pb, Cd, As), tobacco-specific nitrosamines (TSNAs), polycyclic aromatic hydrocarbons (PAHs) (in dust and on surfaces)

Adverse Health Effects of THS:

Genotoxic effects e.g. Oxidative DNA Damage, mutations in Human Cells and Animal Models

- NNA (tobacco specific nitrosamine) forms DNA Adducts

Mitochondrial damage

Multiple organ effects in mice:

- Behavior changes similar to ADHD, development of immunity, wound healing, insulin resistance, and more, at realistic exposure levels

- (e.g. Hang B, Wang P, Zhao Y, Chang H, Mao JH, Snijders AM. Thirdhand smoke: Genotoxicity and carcinogenic potential. *Chronic Dis Transl Med.* 2019;6(1):27-34. Published 2019 Sep 26. doi:10.1016/j.cdtm.2019.08.002
- Adhami N, Starck SR, Flores C, Martins Green M (2016) A Health Threat to Bystanders Living in the Homes of Smokers: How Smoke Toxins Deposited on Surfaces Can Cause Insulin Resistance. *PLoS ONE* 11(3): e0149510. <https://doi.org/10.1371/journal.pone.0149510> pmid:26934053
- Martins-Green M, et al. (2014) Cigarette Smoke Toxins Deposited on Surfaces: Implications for Human Health. *PLoS ONE* 9(1): e86391. <https://doi.org/10.1371/journal.pone.0086391>)

1. What is Thirdhand Smoke?

Where THS has been found in previous research:

- Environments where tobacco is used:
 - Low-income and high-income homes, used vehicles, rental vehicles, hotels, nonsmoker rooms, casinos
- Nonsmoking environments where tobacco had been used regularly.
 - Homes, cars, hotels, casinos, during, and after a smoking ban, homes of quitters to 6 months afterwards, homes where non-smokers moved into former smoker homes (after cleaning)
- Environments regularly visited by active smokers.
 - Neonatal intensive care unit, SDSU labs (had to ban certain people)
- On smokers and on nonsmokers living with smokers
 - Children and homes of smokers who smoke outside



2. Measurement of Thirdhand Smoke

- **Sample Collection:**
- **Wipe sampling** (template, cotton wipe w/ 1 % Ascorbic acid)
- **Dust sampling**
 - HVS3 or 4 Cyclone vacuum into Teflon bottle (particles down to $<5\text{ }\mu\text{m}$) (known surface area) (**best for complex chemical analysis**)
 - Recently, (COVID restrictions) DIY with Dyson vacuum, inside pet fence) or own vacuum bag
- **Extract materials** such as pillows
- **Silicone wristbands** (precleaned, worn or hung in air)
- **Analysis:** isotope-dilution LC-MS/MS or GCxGC-TOF MS (SDSU Hoh lab)



Thirdhand smoke contaminants reported in house dust

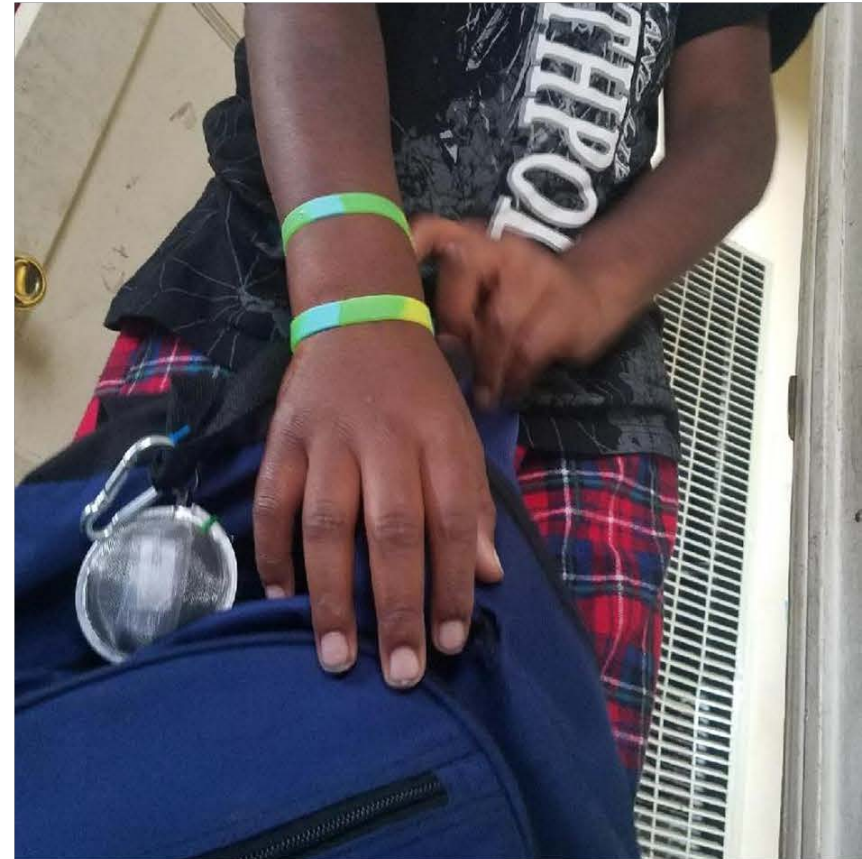
- **Nicotine** (Hein et al., 1991, Matt et al., 2004, 2011, 2016, 2018, Quintana 2013) Other **tobacco alkaloids** (Whitehead et al., 2018),
 - **Tobacco-specific nitrosamines, TSNA**s, incl. NNK (Matt et al., 2016, 2018, 2019, Ramirez et al., 2014, Whitehead 2015)
 - **Metals** (Matt et al., 2021)
 - **Polycyclic aromatic hydrocarbons, PAHs** (Hoh et al., 2012, Whitehead et al. 2011, 2013) (the 16 EPA PAHs), **Oxy-PAHs** identified in THS house dust (Quintana et al. 2021)
 - ? What else? > 4000 toxic chemicals in tobacco smoke (Rodgman and Perfetti, 2013), many have low enough vapor pressure to remain, plus new compounds created by reactions
- **Application of Non-Targeted Analysis**

2. Measurement of Thirdhand Smoke

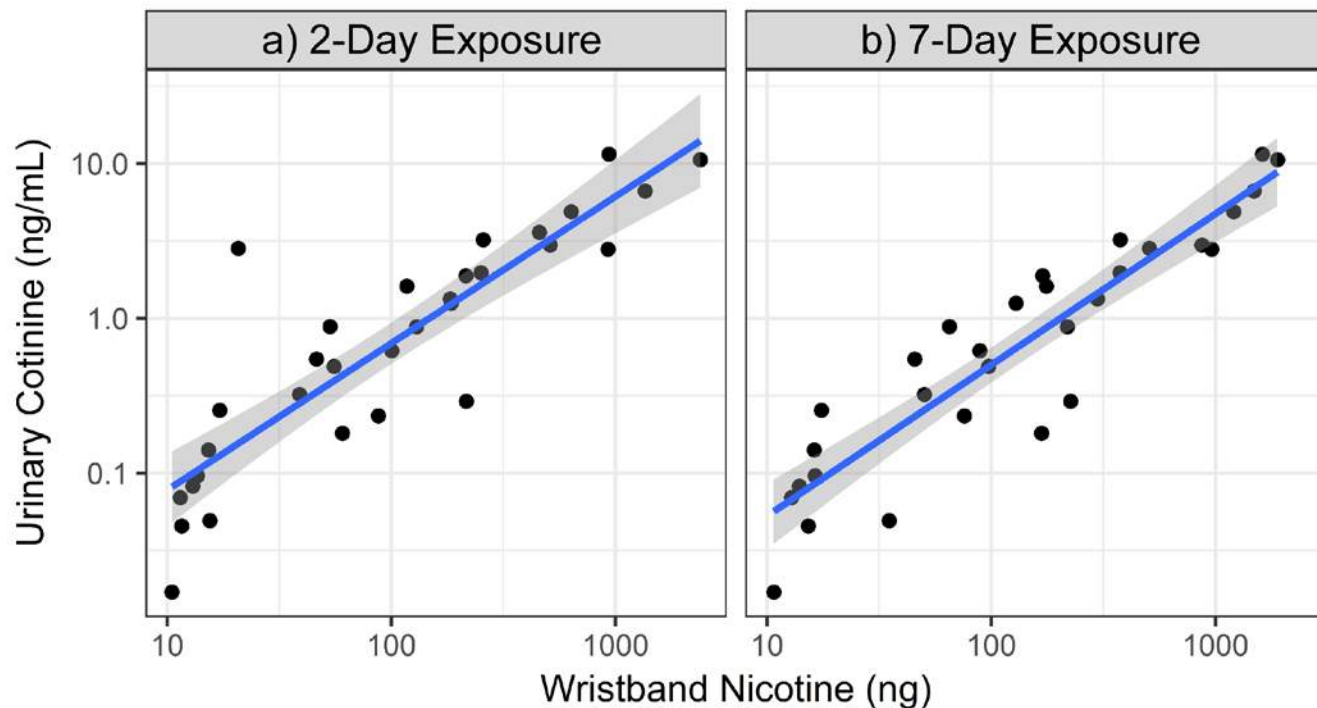


Silicone Wristband Samplers

- Determine if a simple silicone wristband (WB) can detect tobacco-related and e-cigarette toxicant exposures in children
- Determine if levels of these toxicants in WB could discriminate between groups of children exposed to tobacco-products



Silicone wristband samplers for tobacco toxicants



Quintana PJE, Hoh E, Dodder NG, Matt GE, Zakarian JM, Anderson KA, Akins B, Chu L, Hovell MF. **Nicotine levels in silicone wristband samplers worn by children exposed to secondhand smoke and electronic cigarette vapor are highly correlated with child's urinary cotinine.** *J Expo Sci Environ Epidemiol.* 2019 Oct;29(6):733-741.

CRITICAL REVIEW

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Cite this: DOI: 10.1039/d0em00194e

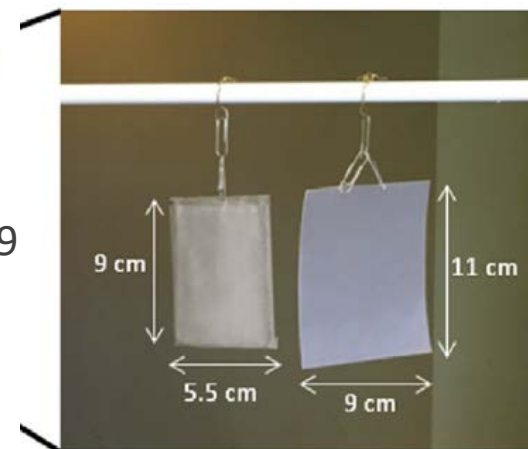
Passive air sampling for semi-volatile organic chemicals

Frank Wania * and Chubashini Shunthirasingham †

Reviews PDMS samplers and sampling rates –

Sheets of PDMS hung up (see right from Okeme et al 2016 - 11 x 9

- Aluminum backed personal 'brooches'
- Sheets of PDMS in a petri dish
- Stir bars coated with PDMS
- SPME - direct thermal desorption



3. Example: THS in Multiunit Housing

U.S. HUD: Healthy Homes Technical Studies Grant Program Thirdhand Smoke Screening and Remediation in Low Income Housing

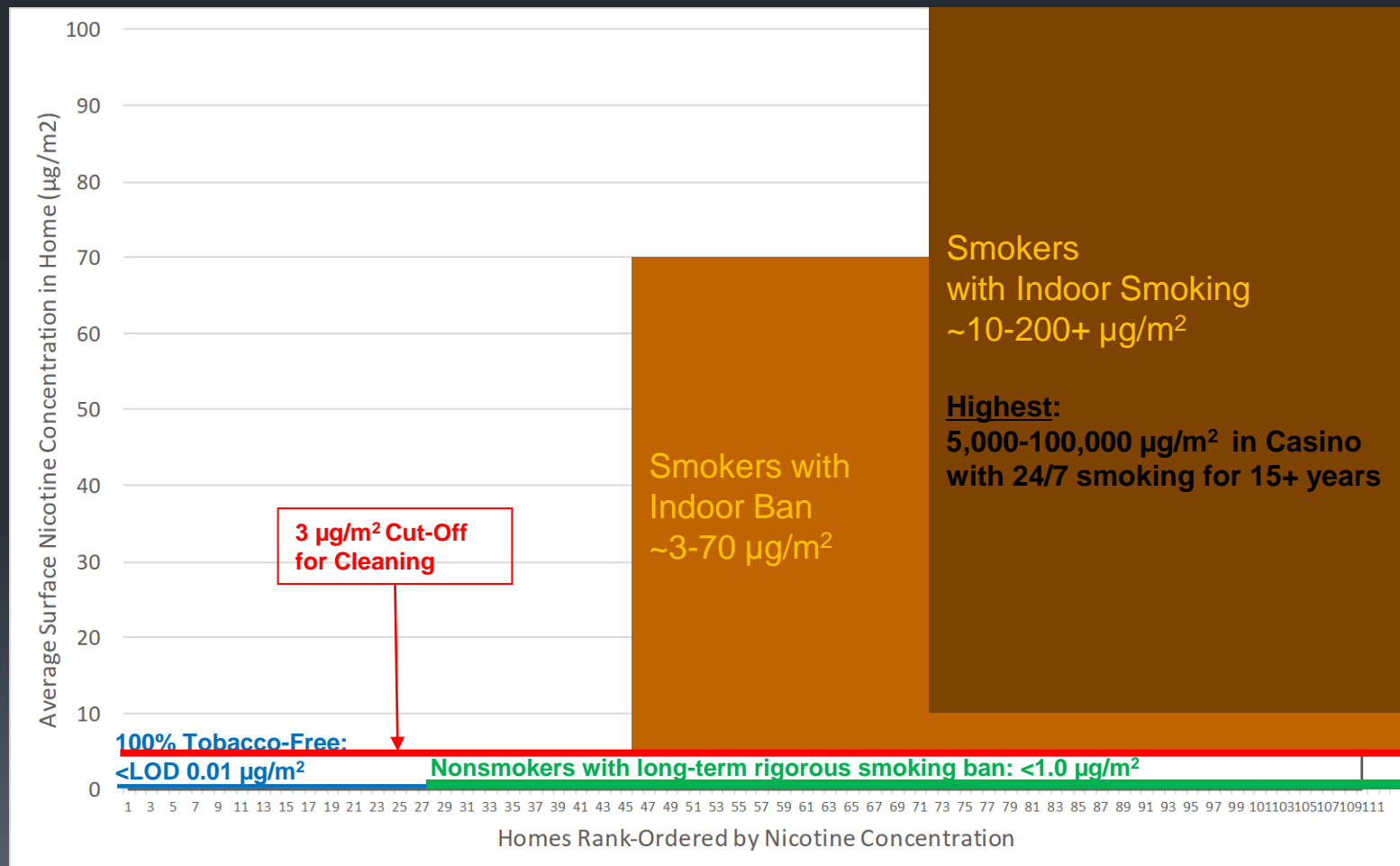
Recruitment

- Low-income buildings identified using Countywide Affordable Housing Inventory list
- Managers contacted for permission & surveyed
- Posted flyers and went door-to-door
- Participants eligible if: 18 years or older, lived in the unit, were Section 8 or low-income
- Community workers: Delivered survey in: English, Spanish, & Somali (Arabic was not used but was available)



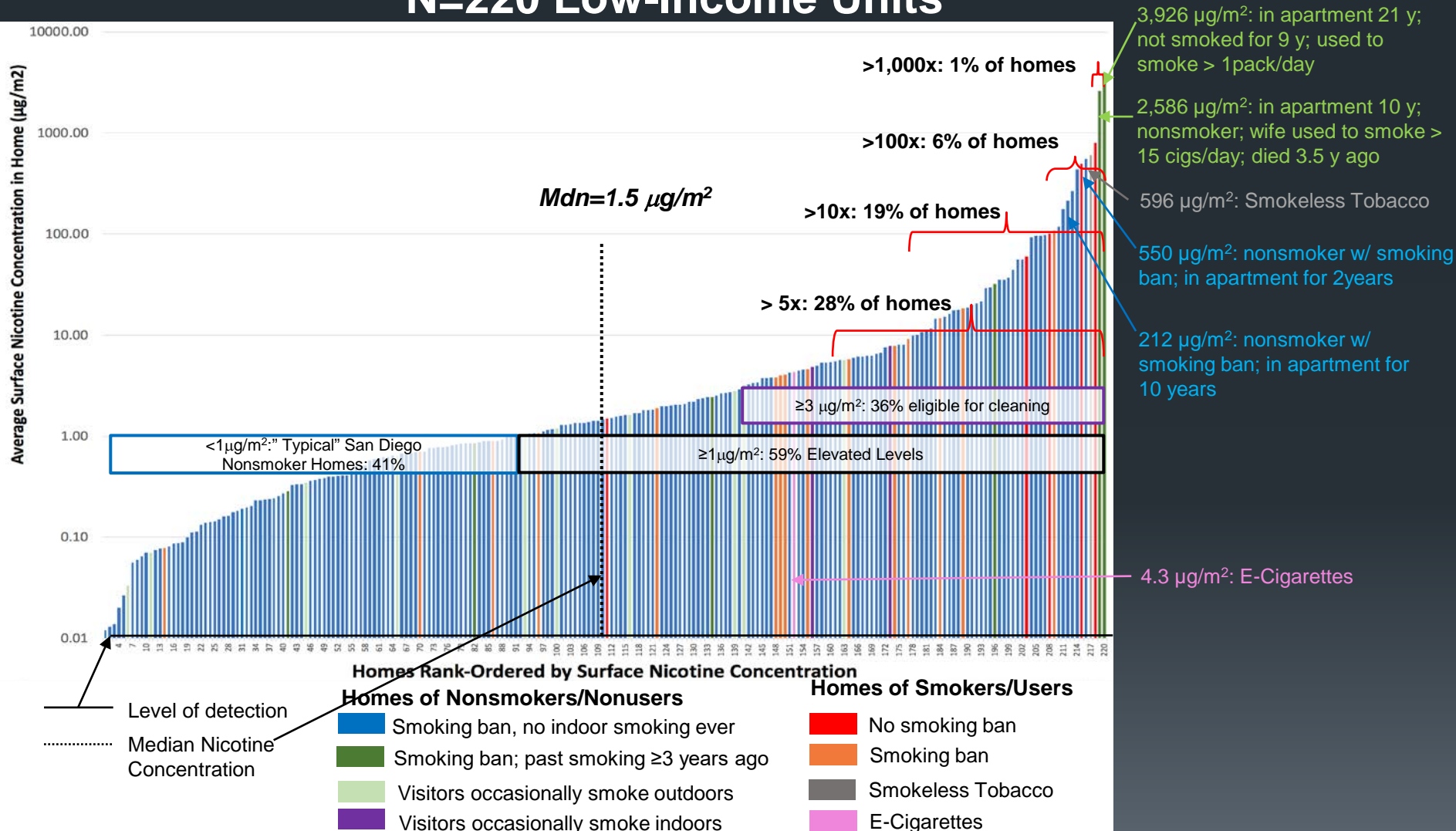
3. THS in Multiunit Housing

Expected Nicotine Surface Concentrations based on Previous Research (Level of Detection: $0.01 \mu\text{g}/\text{m}^2$)



3. Prevalence of THS in MUH

Distribution of Nicotine Surface Concentrations in N=220 Low-Income Units



3. Thirdhand smoke in the workplace

- Thirdhand smoke residue can stay on clothes, items, or seating after smoking has stopped, thereby exposing others who come into contact with those items (e.g. truck interior).
- Certain occupational groups are more likely to be exposed to thirdhand smoke in their workplaces (even in CA!), for example
 - Casinos
 - Hotel cleaners
- Take-home exposures can be a concern, as children are most at risk
- Case Study – THS Resource Center approached by truck driver

The Case of the USPS Worker

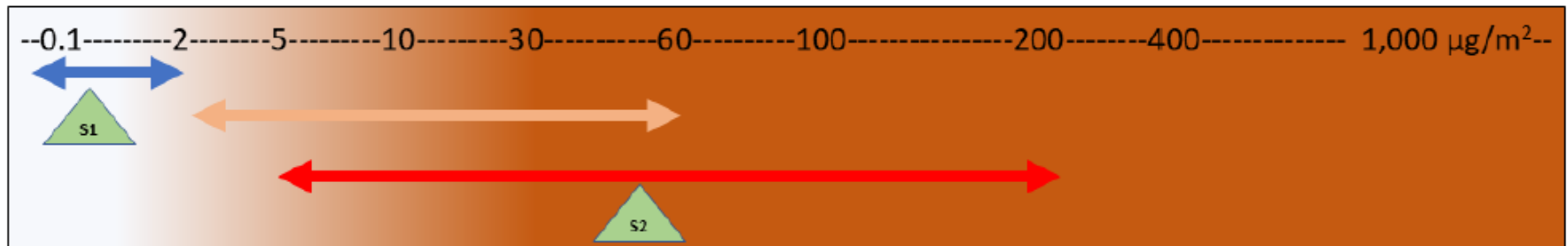


Truck driver case study

Results – surfaces in ‘clean’ and ‘dirty’ vehicle

Table 1: Surface Nicotine	
Locations	Nicotine $\mu\text{g}/\text{m}^2$
S1: Clean vehicle	0.6
S2: Dirty vehicle	51.7

Figure 1: Observed **surface wipe** nicotine levels in workplace vehicles (micrograms of nicotine per square meter, $\mu\text{g}/\text{m}^2$; green triangles) with reference levels from nonsmokers (blue) and smokers with (light red) and without (dark red) indoor smoking bans.



Truck driver case study - Results: silicone wristbands

2.2 Nicotine in Wristbands

Four wristbands were deployed to measure nicotine. Two adults each wore one wristband, and one wristband was hung in each vehicle. All wristbands were deployed for 7 days (168 hours), with no exceptions. The wristbands were analyzed for nicotine level.



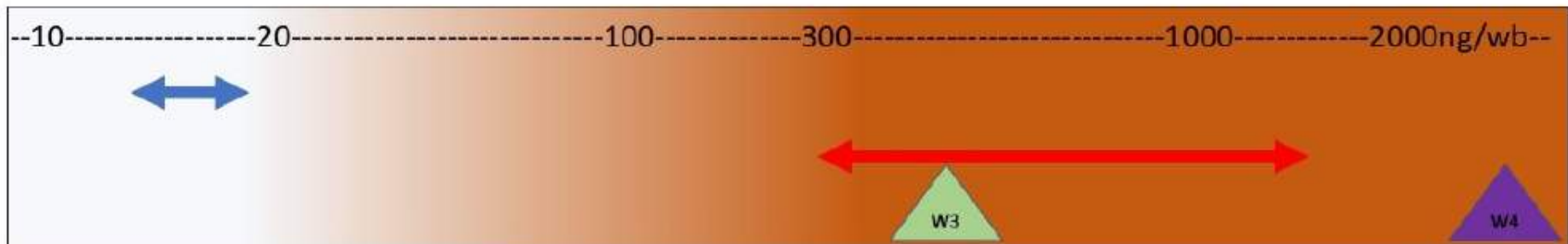
Table 2: Nicotine in Wristbands	
Locations	Nicotine ng/wristband
W1: 	21.0
W2: 	10.4
W3: Clean Vehicle	408.8
W4: Dirty Vehicle	20201.6

Figure 3: Observed wristband nicotine levels in wristbands deployed in workplace vehicles (nanograms of nicotine per wristband; green triangle “clean” vehicle and purple triangle “dirty” vehicle) with reference levels from children of nonsmokers (blue) and smokers who smoke indoors (dark red).



4. Smoke-free workplaces

- What is (not) permitted re: smoking. Smokefree policies may not be clear about where smoking is allowed (e.g., company vehicles); lack of enforcement. CA law prohibits discrimination based on smoking status or history
- Most workplaces have smoking indoors banned but not all: Indoor club? Cigar shop? Marijuana dispensary? Casinos? Smoking hotel rooms? How do we protect those employees?
- Vaping sometimes not considered smoking
- **Actions:**
 - Identify at-risk workplaces and be clear about policies
 - **Define where it is and is not permitted**
 - **Detail repercussions**
 - **Enforce rules**
 - Prevent take-home
 - Allow employees to change/shower before leaving work
 - Provide interventions
 - Fund cessation programs

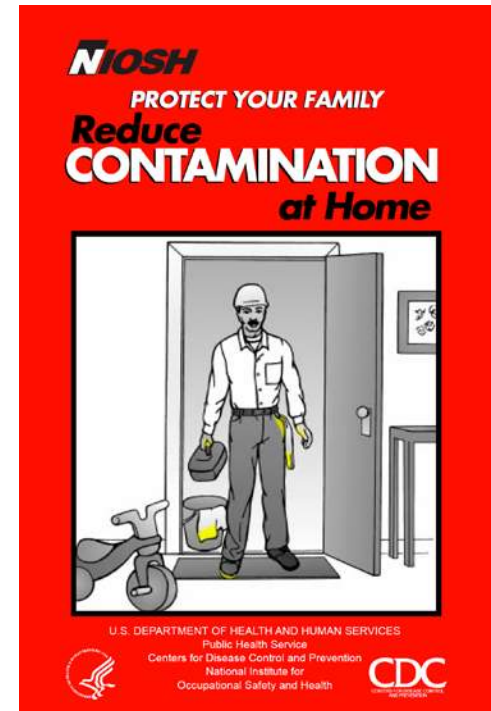
Take-home exposures

Known hazard for lead, pesticides, asbestos, others, contaminates dust, laundry

- Report to Congress on Workers' Home Contamination Study Conducted Under The Workers' Family Protection Act (29 U.S.C. 671a) September 1995 DHHS (NIOSH) Publication Number 95-123 <https://www.cdc.gov/niosh/docs/95-123/pdfs/95-123.pdf?id=10.26616/NIOSH PUB95123>
- (brochure) <https://www.cdc.gov/niosh/docs/97-125/pdfs/wkhmcn.pdf?id=10.26616/NIOSH PUB97125>

Even vehicles!

- Car seats - Childhood Lead Poisoning Associated with Lead Dust Contamination of Family Vehicles and Child Safety Seats --- Maine, 2008. CDC MMWR August 21, 2009 / 58(32);890-893 <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5832a2.htm>



Resource guide

https://thirdhandsmoke.org/wp-content/uploads/2021/02/ResourcePacket_Workplaces.pdf



Resource Kit: Workplaces and Thirdhand Smoke

This packet provides accessible explanations of what thirdhand smoke is, how it behaves, its consequences, and why it matters for workplaces. Each of the following 9 questions and more can be found in English at <https://thirdhandsmoke.org/faq/> or in Spanish at <https://thirdhandsmoke.org/category/pregunta-de-la-semana/>.

What is thirdhand smoke and why should I care?

1. What surfaces does tobacco smoke stick to? [\[English\]](#) [\[Español\]](#)
2. What tobacco products contribute to thirdhand smoke? [\[English\]](#) [\[Español\]](#)
3. How are you exposed to thirdhand smoke? [\[English\]](#) [\[Español\]](#)
4. What do we know about the health risks of thirdhand smoke? [\[English\]](#)
5. Are there tests for thirdhand smoke? [\[English\]](#)

What does thirdhand smoke have to do with workplaces?

6. People can still bring in thirdhand smoke to the workplace [\[English\]](#) [\[Español\]](#)
7. Some policies protect workers from thirdhand smoke in the workplace [\[English\]](#)
8. Thirdhand smoke decreases the value of property [\[English\]](#)
9. Smokefree properties save lives and money [\[English\]](#) [\[Español\]](#)
10. The CDC has concluded that people in certain industries experience greater secondhand smoke, the precursor to thirdhand smoke [\[English\]](#)
11. Other companies have adopted smoke-free policies [\[English\]](#)

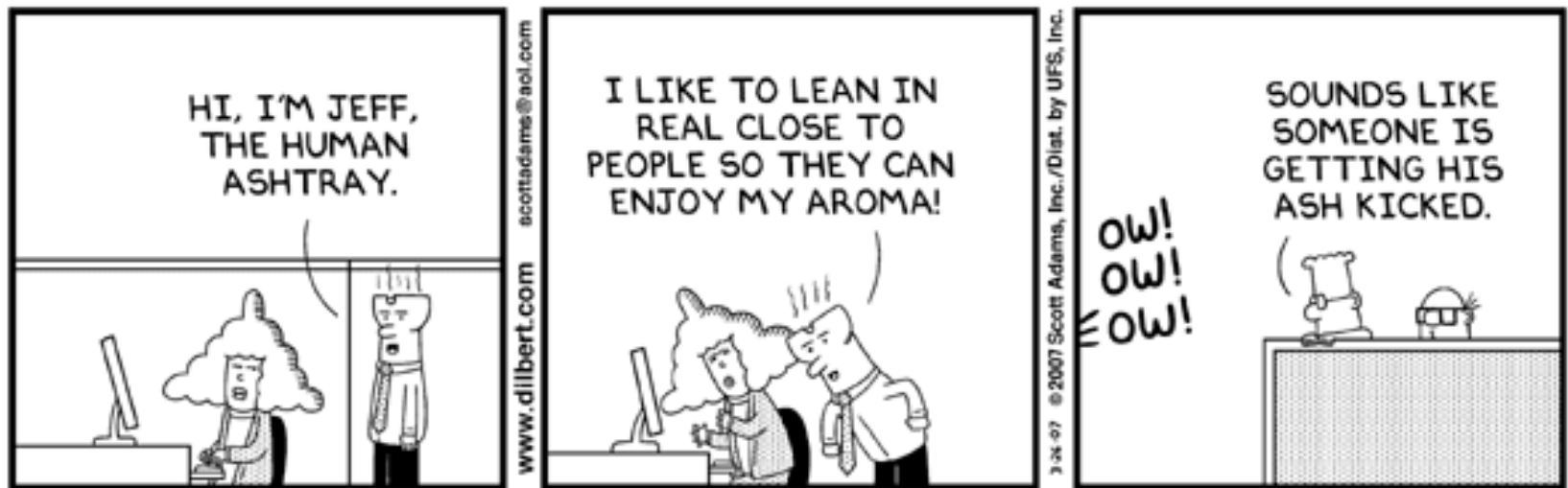
5. Future Directions

1. Research Questions

- What are harmful components of thirdhand smoke?
- What are predictive markers of thirdhand smoke?
- Can we develop rapid tests for thirdhand smoke?
- How can we remediate THS?

2. Policy questions

- How much thirdhand smoke contamination is OK?
 - Quantitative limits for surfaces, dust
 - Should these be based on risk (using traditional risk assessment approaches)?
 - Or norms? (levels found in long-term non-smoking environments)?
- Disclosure (e.g. real estate, rentals)
- Testing



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Thank you!

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For scientific publications:

<https://thirdhandsmoke.org/research/thirdhand-smoke-research-collection/>

Contact me at: jquintan@sdsu.edu

Silicone wristband have promise for THS detection

Quintana PJE, Lopez-Galvez, NI, Dodder NG, Hoh E, Matt GE, Zakarian JM, Vyas, M, Chu, L, Akins B, Padilla, S, Anderson KA, Hovell MF. Nicotine, cotinine and tobacco-specific nitrosamines (TSNAs) measured in children's silicone wristbands in relation to secondhand smoke and e-cigarette vapor exposure. 2020. *Nicotine & Tobacco Research (in press)*

Table 2. Child's exposure group related to nicotine and cotinine concentrations in wristbands, nicotine in air and urinary cotinine.

Exposure group by classification scheme (#)	n*	7-day Wristband Nicotine Concentration (ng/g), n = 52 Median (p25–p75)	Urinary Cotinine Concentration (ng/ml), n = 53 Median (p25–p75)
Child's reported exposure (II)			
NS-Non-exposed by caregiver report	24	4.5 (3.1–28.2)	0.1 (0.1–0.3)
EC	14	27.6 (15.1–58.0) ^a	0.5 (0.3–1.2) ^a
EC+CC	4	176.2 (55.7–561.3) ^a	2.4 (1.9–8.1) ^a
CC	9	242.4 (105.9–470.8) ^{a,b}	4.2 (3.2–7.6) ^{a,b}

N=24 : 10 'unexposed' children –caregivers used CC/EC vs. 14 children –caregivers did not use CC/EC

WB nicotine **46.5 ng/g** (19.8 – 207.3) vs **3.9 ng/g** (1.6-5.4) p<0.05