Health Canada Santé Canada

Canada

Occupational Exposures of Firefighters to Toxicants of Concern

Collaborative Projects involving University of Ottawa[1], Ottawa Fire Services[2], Health Canada[3], University of Toronto[4], Université Laval (INSPQ)[5], University of Copenhagen[6] and McGill University[7]

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YOUR HEALTH AND SAFETY... OUR PRIORITY.

Firefighters' Risk of Chronic Diseases, e.g., Cancer

- Several studies have documented significant increases in cancer incidence (>6-fold) and mortality (>2-fold)

Florida
Male FFs
Bladder ca
Testicular
Thyroid ca

Female FFs
Overall ca
Cervical ca
Thyroid cancer (SIR=4.0)
Hodgkin disease (SIR=6.3)

delphia

International Agency for Research on Cancer (IARC) classified 'occupational exposure as a firefighter' as possibly carcinogenic (IARC, 2010)

Re-assessment in June 7-14, 2022, IARC Monograph 132

Ma et al (2006) *J Occup Environ Med* 48(9), 883-888; Daniels et al. (2014) *Occup Environ Med* 71(6): 388-397.

Exposures to PAHs, Metals and Organic Mutagens During Emergency Fire Suppression

Environmental Science & Technology

Article

pubs.acs.org/est

Elevated Exposures to Polycyclic Aromatic Hydrocarbons and Other Organic Mutagens in Ottawa Firefighters Participating in Emergency, On-Shift Fire Suppression

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FIRE – INCENDIE Ottawa

Institut national de santé publique Québec

uOttawa

Ontario MINISTRY OF LABOUR

UNIVERSITY OF TORONTO

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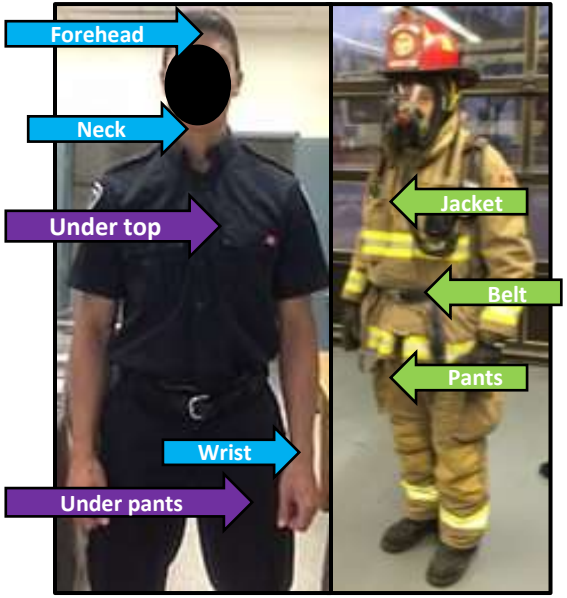
Study Samples

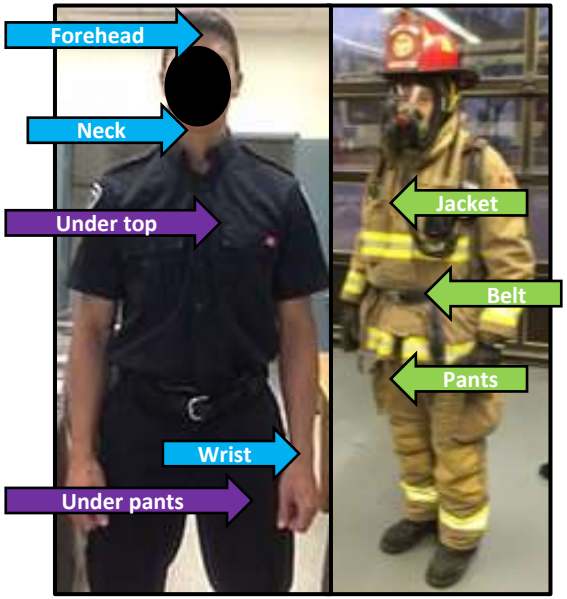
- 29 paired (pre- and post-fire) dermal wipe and urine samples collected at 19 fires, matching active air samples
- Ottawa fire service office workers, and CHMS (Canadian Health Measures Survey) males of same age-range, as controls

Sample Collection

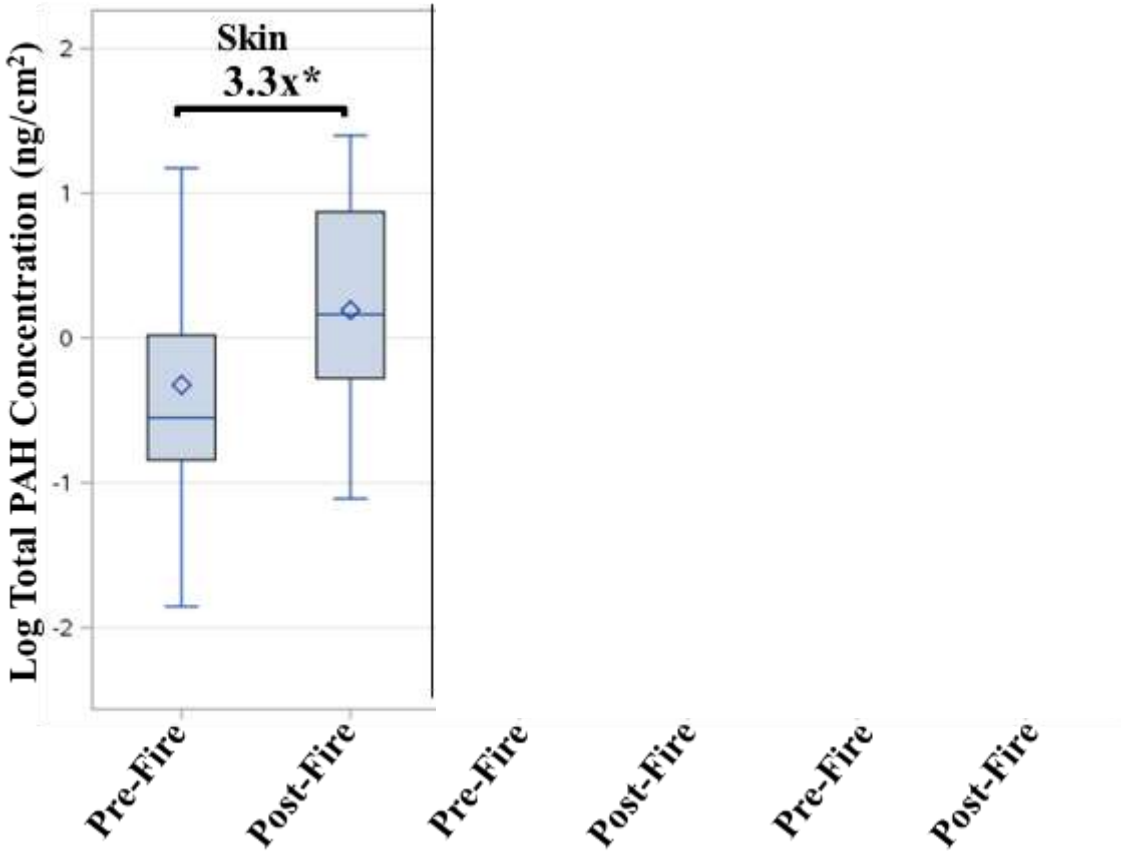
Beginning of Shift

- Urine Sample
- Skin wipes
- PPE wipes
- Under gear wipes



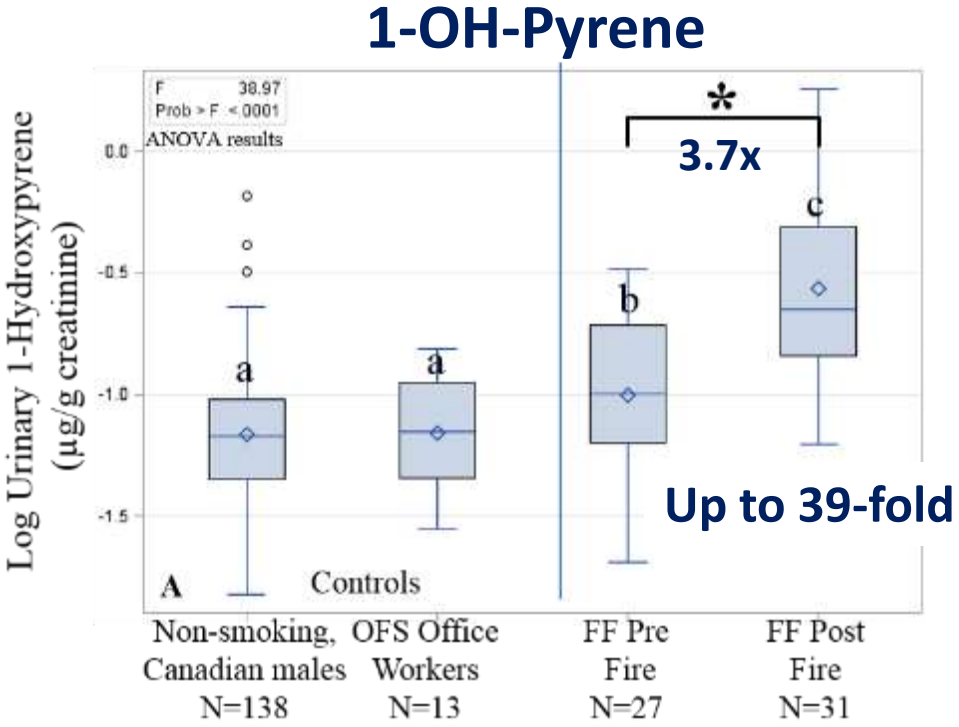


Significant Increases in Post-suppression Surface Contamination



*p<0.05, ***p<0.001

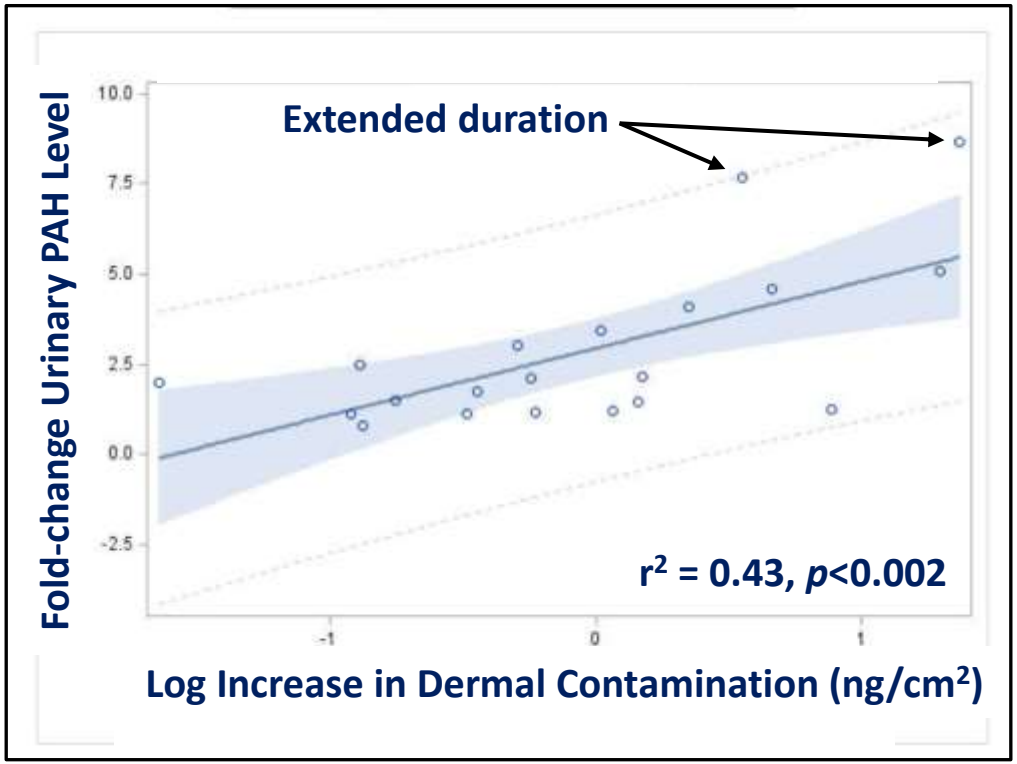
Significant Increases in Post-suppression Urinary Concentration of PAH Metabolites



Similar results for other PAH metabolites:

- OH-Phenanthrenes 5.3x, up to 63-fold
- OH-Fluorenes 3.9x, up to 12-fold
- OH-Naphthalenes 2.9x, up to 12-fold

Dermal Contact is an Important Determinant of Urinary PAH Metabolite Levels, i.e., Internal Dose



- No changes in lung injury biomarker (i.e., CC16)
- Relationship between urinary PAH metabolite concentration and increase in areal skin contamination level (p<0.002)
- Numerous studies – dermal contact more influential than inhalation
- Excessive level of urinary metabolites in individual who forgot to wear a flash hood

Derived from Keir *et al* (2017) *Environ. Sci. Technol.* 51:12745.

What to do About Dermal Exposures?

Improve occupational working conditions?

Avoid initial exposure?

Improve PPE?

Post-exposure dermal decontamination?

ACTION WIPES®

FIREWIPES
EST. 2015

RESCUE WIPES

hero wipes

RESPONDER® WIPES

Uniquely Formulated Wipes Developed for Firefighters to

REMOVE THE RISK

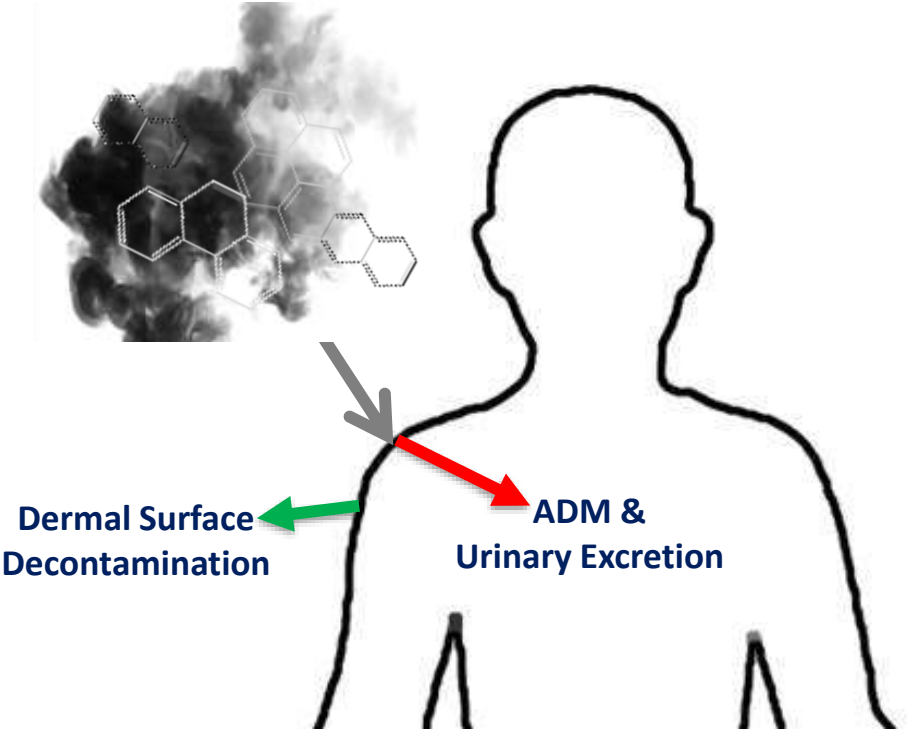
Dermal Cleaning Procedures to Reduce Firefighters' Exposures to Combustion-derived Polycyclic Aromatic Hydrocarbons (PAHs)

- Canadian Forces Fire Marshal
- International Association of Fire Fighters
- Ottawa Professional Fire Fighters' Association
- Association des pompiers de Montreal
- Institut de protection contre les incendies du Quebec
- Health Canada

Objectives

Efficacy of dermal decontamination, i.e., to reduce exposure

1. **How much is being removed from the surface?**
2. **Does dermal decontamination reduce internal dose?**
3. **Does dermal decontamination reduce DNA damage in urothelial cells?**
4. **Are some decontamination methods better than others?**



Sample Collection

- **Live fire training fall 2018 and spring 2019**

- **3 decon methods:**
  - **Commercial Wipe A**
  - **Commercial Wipe B**
  - **Soap & water**
  - **No decon (control)**

Sample Collection

Pre-Fire

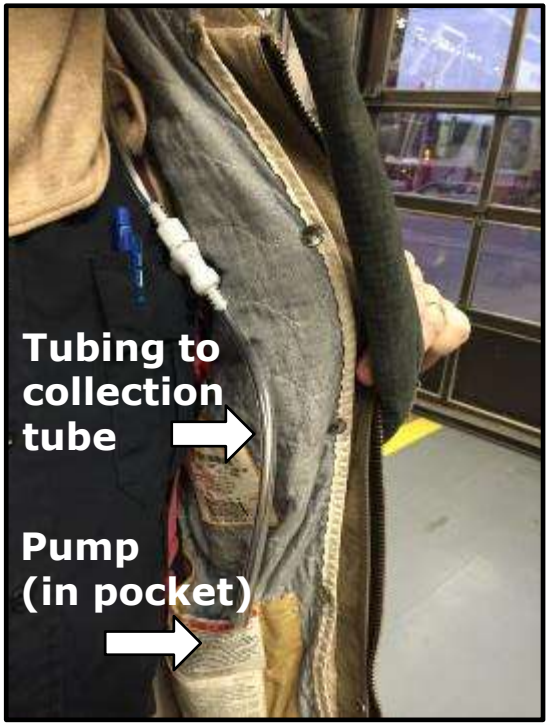
Sample Collection

Pre-Fire

- Urine Sample
- Skin wipes

During Fire Event

- Personal air sampling



Sample Collection

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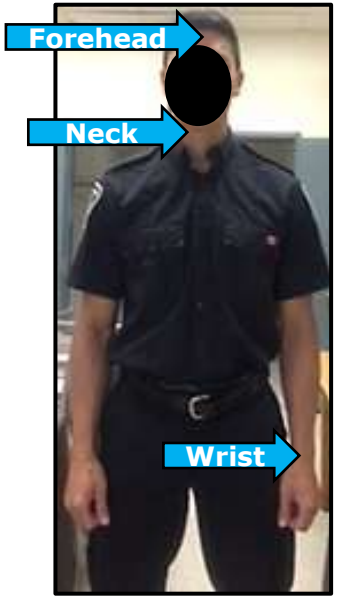
Pre-Fire

- Urine Sample
- Skin wipes

During Fire Event

- Personal air sampling
- Passive sampler



Sample Collection

Pre-Fire

- Urine Sample
- Skin wipes

During Fire Event

- Personal air sampling
- Passive sampler

Post-fire

- Skin wipes

Sample Collection

Pre-Fire

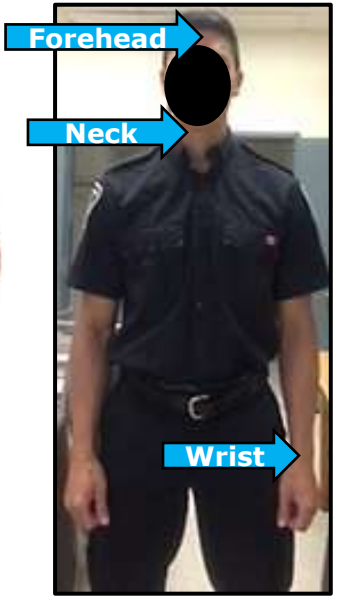
- Urine Sample
- Skin wipes

During Fire Event

- Personal air sampling
- Passive sampler

Post-fire

- Skin wipes



Decontamination

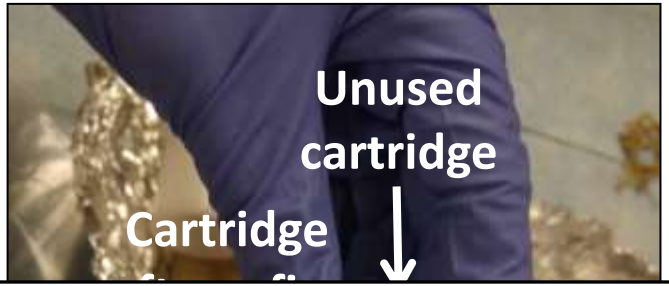
Randomly assigned:

- No decon
- Soap & Water
- Wipe A
- Wipe B

Post-decon

- Skin wipes (repeat)
- 18-hr integrated urine sample

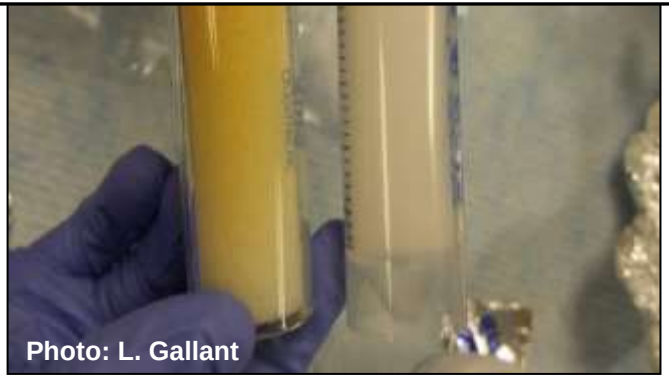
Results – Air Contamination



Is the environment contaminated with PAHs?

Average Total PAH Concentration = 358µg/m³ (up to 663 µg/m³)

Highest Urban Toronto = 5-30 µg/m³ (Jariyasopit *et al*., 2019, Environ Pollut 252:1882)



Skin Surface Wipes

Does the dermal surface become contaminated?
Significant 1.9-fold increase in dermal (total) PAH contamination (p<0.01), Maximum fold-change = 25.3

Does decontamination effectively remove PAHs from the skin surface?

Post-decontamination Changes in Skin Contamination Levels
- Fold-changes Relative to Post-fire -

		Wipe A	Wipe B	Soap & Water
Compound(s)	N	Geometric mean contamination fold change post-decon/post-fire		
Total PAHs	22	1.02	0.77	0.53**
LMW PAHs	22	1.03	0.81	0.58**
Pyrene	22	0.76	0.49	0.29**
Retene	22	0.97	0.56	0.41**
Benz(*a*)anthracene	22	0.92	0.44	0.28**
Chrysene	22	0.76	0.70	0.27**
Benzo(*b*)fluoranthene	22	1.00	0.99	0.97
Benzo(*ghi*)perylene	22	1.55	1.57	0.88

Does decontamination remove PAHs from the dermal surface?

Soap and water – significant reduction in areal PAH contamination; removed about half of the dermal PAHs

None of the other interventions significantly reduced dermal contamination

* $p<0.05$
** $p<0.01$

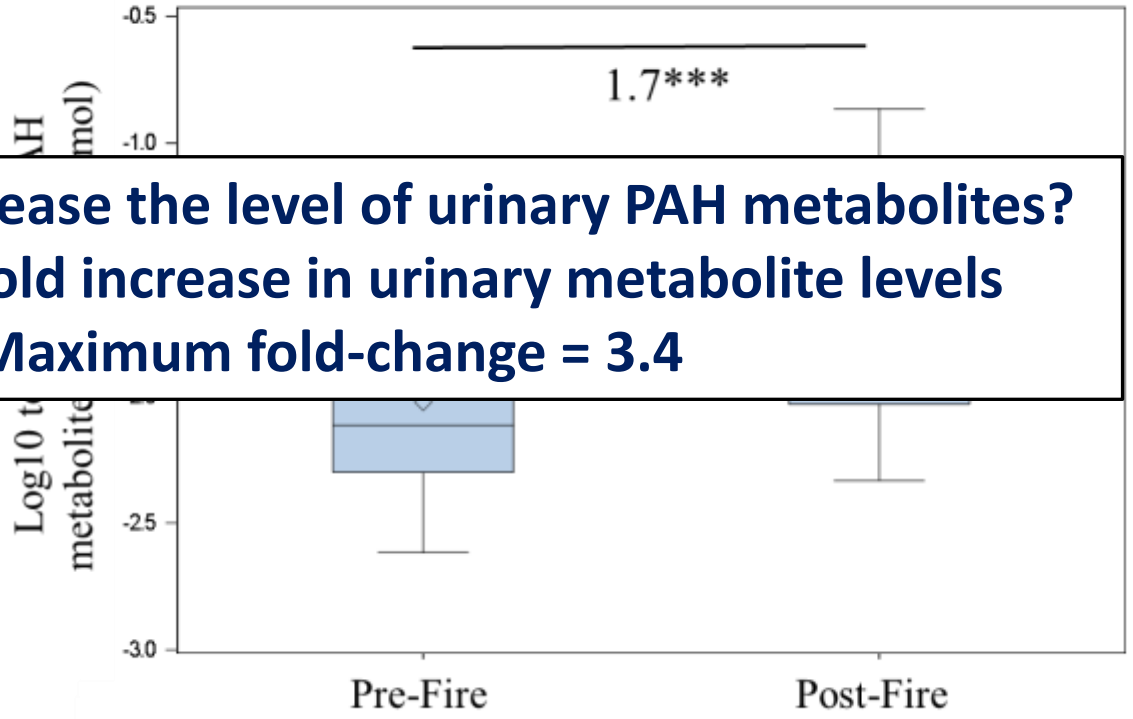
Post-fire Changes in Osmolality-corrected Urinary PAH Metabolite Levels

Significant ↑ in metabolites of:

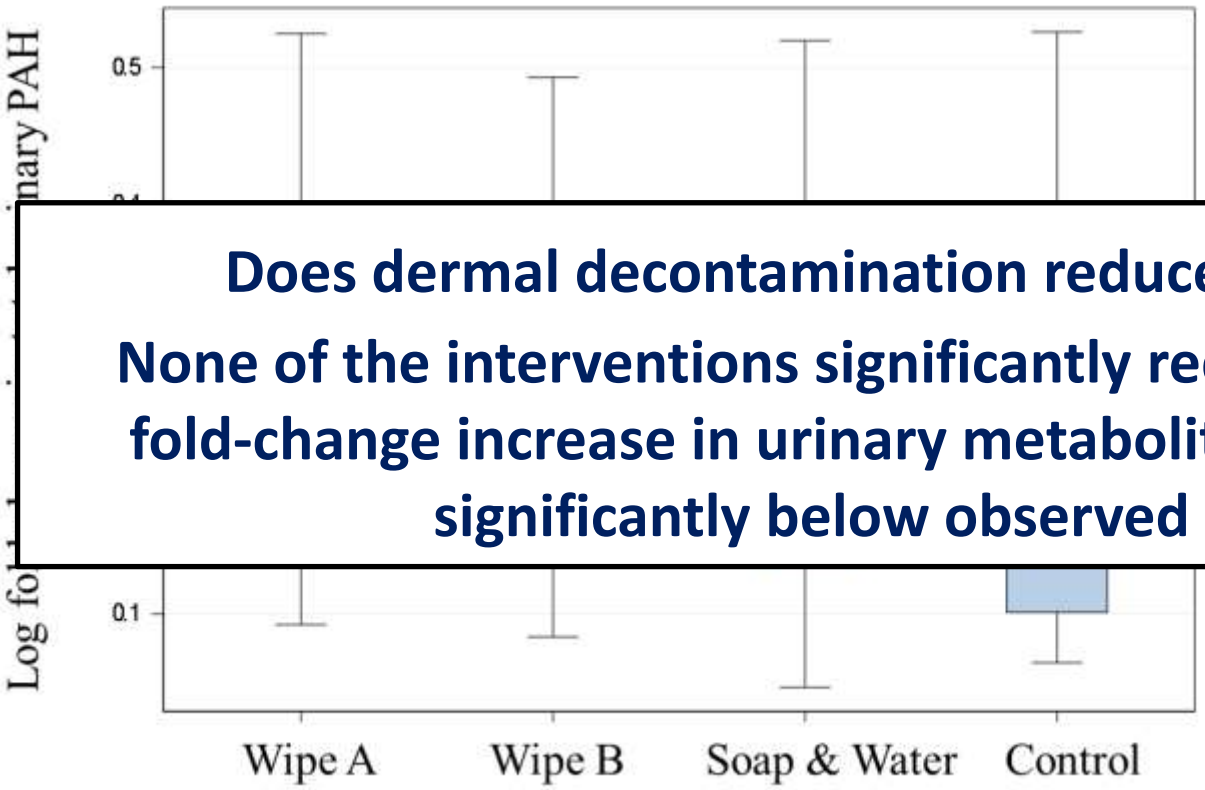
- **Pyrene (2.2x)**

Does fire suppression increase the level of urinary PAH metabolites? Significant 1.8- to 2.2-fold increase in urinary metabolite levels (p<0.01). Maximum fold-change = 3.4

✓ **Significant internal dose**



Effect of Dermal Decontamination on Post-fire Increase in Urinary Metabolite Levels



Average 1.7-fold Post-versus-Pre Increase, $p<0.001$

Does dermal decontamination reduce internal dose?

None of the interventions significantly reduced the observed fold-change increase in urinary metabolite levels, i.e., never significantly below observed 1.7-fold

Silicone Wristbands – Results to Date

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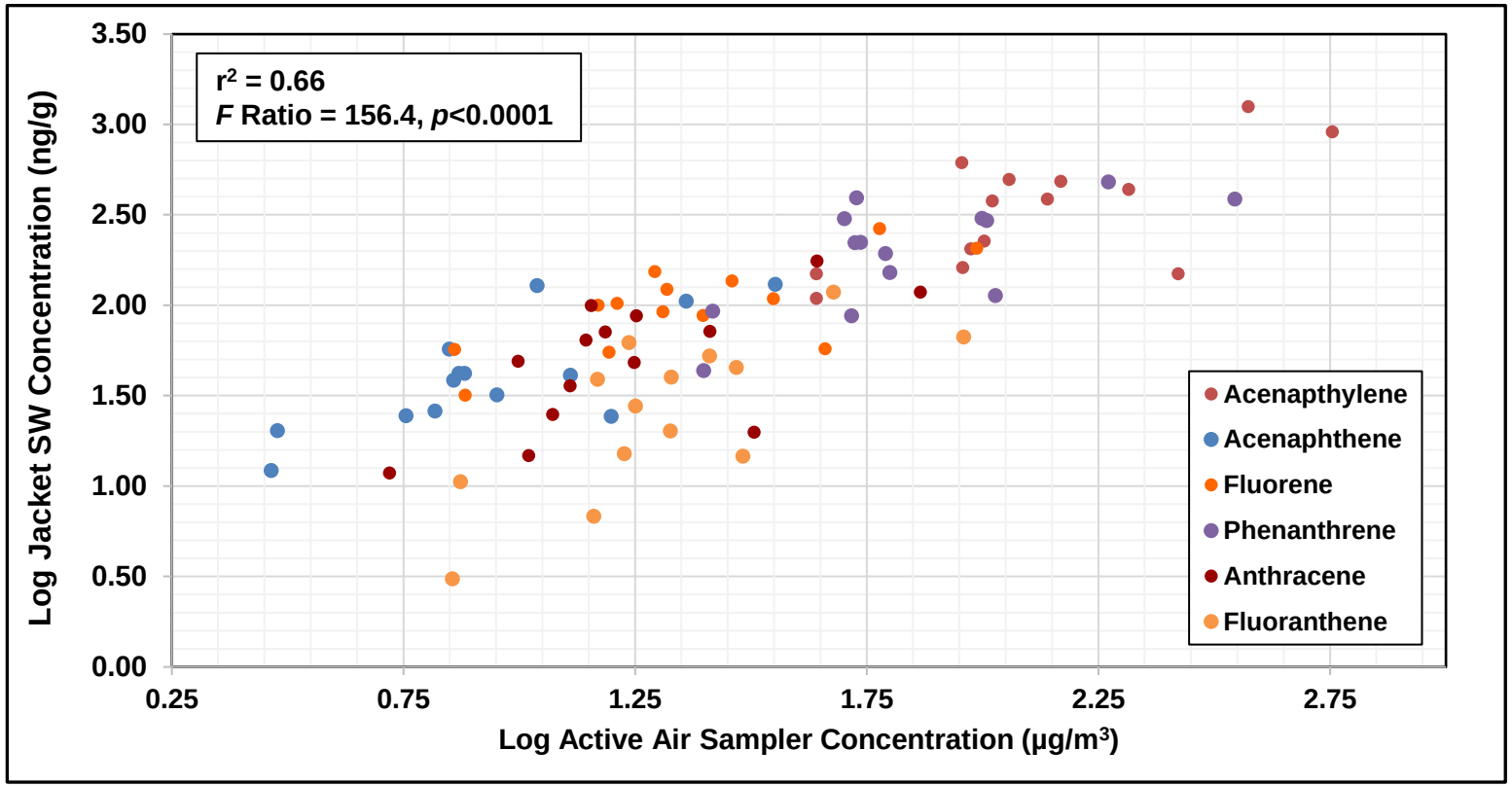
- Significant correlation between SW-jacket values & active air values
- Significant correlation between SW-jacket values & levels of 4 urinary metabolites
- No correlations between SW-wrist values & urinary metabolite levels



Dermal Decontamination Study - Summary of Findings

- ✓ Training environment is heavily contaminated with airborne PAHs.
- ✓ Significant dermal deposition of PAHs.
- ✓ Areal dermal PAH level is significantly reduced by Soap and Water decontamination.
- ✓ Significant post-fire increase in urinary PAH metabolite levels.
- ✓ None of the dermal decontamination strategies reduced the post-fire increases in urinary PAH metabolite levels.
- ✓ SWs useful for passive sampling at fire suppression scene.
- ✓ Why can't the internal dose be reduced by dermal decontamination?

None of This Could Have Happened Without Jennifer Keir!!

Collaborative Study Led by McGill University

Principal Investigator: Prof. Jonathan Chevrier, McGill University
Collaborating Partner: Dr. Cariton Kubwabo, Health Canada

Prof. Jonathan Chevrier

Dr. Cariton Kubwabo

McGill University

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Institut national de santé publique Québec

Sécurité incendie Montréal

- **Pilot Study investigating Montreal firefighters' exposure to selected chemicals; HC collaboration with McGill University and the INSPQ.**
- **INSPQ: Serum/plasma biomonitoring for PFAS, PCBs, brominated flame retardants, dioxins, furans, and heavy metals (i.e., Pb, Cd, Cr, Cu, Mn).**
- **Health Canada: Urinary biomonitoring for organophosphate esters (OPE) flame retardants or plasticizers, polycyclic aromatic hydrocarbons (PAHs), and bisphenols (e.g., bisphenol A).**
- **Results will be published end of 2022 following completion of data analyses, interpretation, and communication to study subjects.**

Government of Canada's Firefighter Action Plan

Government of Canada announces action plan to protect firefighters from harmful chemicals

From: Environment and Climate Change Canada

News release

August 11, 2021 – Ottawa (Ontario)

- Implement a comprehensive action plan to protect Canadians, including firefighters', from exposure to toxic flame retardants found in household products.

Health Canada / Santé Canada

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Assessment & Management of Chemicals

- Short-term Actions
  - Collection, curation and analysis of published human biomonitoring and environmental contamination data. Analyses and interpretation underway. 1000's of observations.

Research, Monitoring & Surveillance

- Short-term actions
  - Complete current biomonitoring initiatives, e.g., McGill/Montreal Fire Service, uOttawa/Ottawa Fire Services.
- Long-term Actions
  - Undertake new collaborative biomonitoring initiatives, e.g., HC-led study to assess firefighters' exposures to flame retardants and PFAS during emergency, on-shift suppression of municipal structural fires. Ongoing.

https://www.canada.ca/en/environment-climate-change/news/2021/08/government-of-canada-announces-action-plan-to-protect-firefighters-from-harmful-chemicals.html

Literature Review – Prioritized Contaminants in Dust & Air

PBDEs in Fire Hall and House Dust – Data from Gill et al. (2020) and Banks et al. (2020)

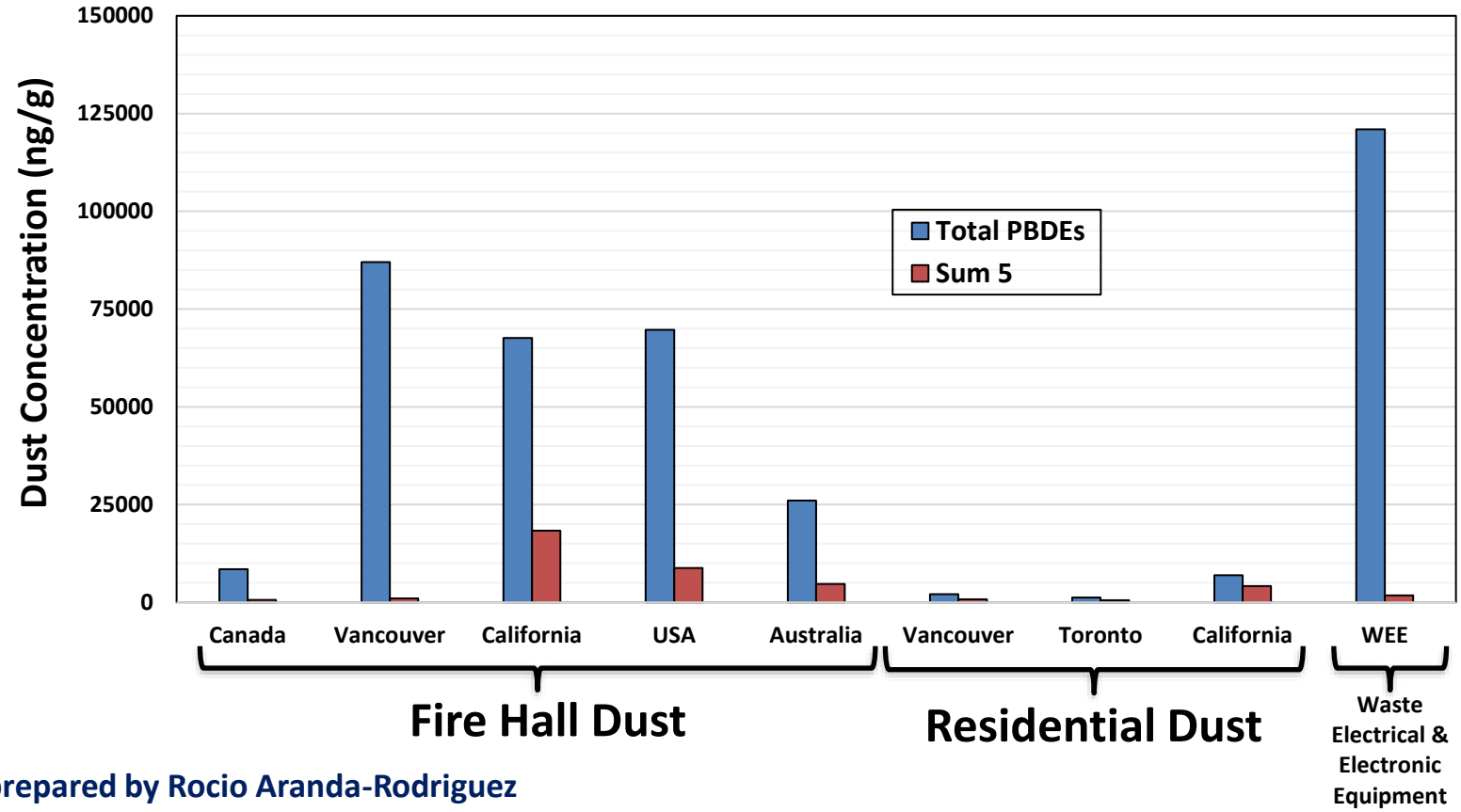
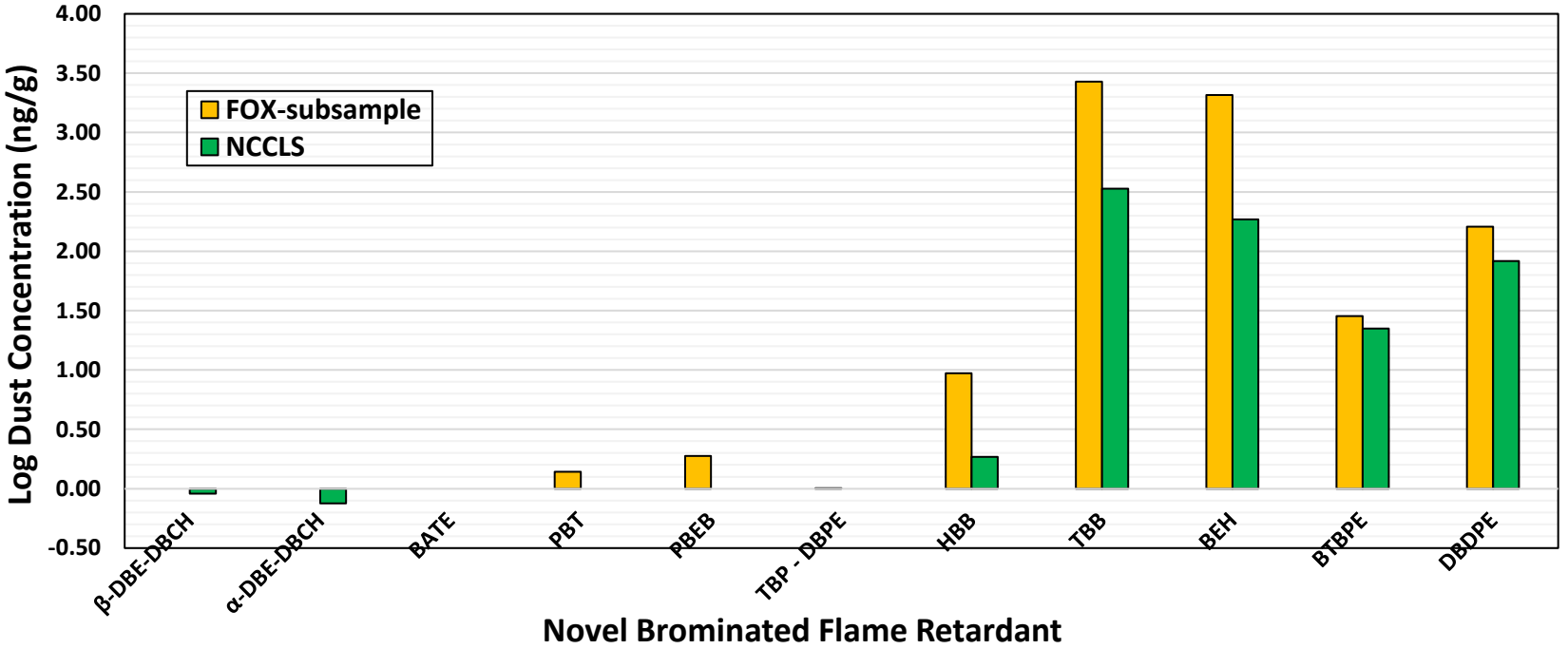


Figure prepared by Rocio Aranda-Rodriguez

Novel Brominated Flame Retardants (i.e., PBDE Replacements) in Fire hall and House Dust



FOX (Firefighters Occupational Exposures) study
Northern California Childhood Leukemia Study (NCCLS) - residential dust

Additional work reviewing air contamination data
Total≈1800 dust and air observations

Figure prepared by Rocio Aranda-Rodriguez

Current Research – Occupational Exposure of On-shift Ottawa Firefighters to Halogenated and Organophosphate Flame Retardants (FRs), and Per- and Polyfluoroalkyl Substance (PFAS

Some studies have investigated FFs' exposures to some FRs and PFAS; no studies have conducted comprehensive assessment of occupational exposures related to *emergency, on-shift suppression of municipal structural fires*.

- **Employ passive samplers (i.e., silicone wristbands) to monitor exposures at the fire suppression scene, in fire hall, and in truck cabs.**
- **Collection & analysis of fire hall dust - to provide additional information about occupational exposure sources.**
- **Dust & SWs analysed for extensive array of PFAS, halogenated FRs & organophosphate FRs.**
- **Results will form the foundation for design of a follow-up biomonitoring study to assess the internal dose of FRs, i.e., levels of FRs in blood, or FR metabolites in urine.**
- **Results will provide valuable knowledge about on-shift FFs' exposures to FRs and PFAS; addressing IAFF concerns and supporting GOC Action Plan. Results will be communicated to a wide range of local, national, and international stakeholders.**

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Ottawa

Concluding Remarks

- ✓ Firefighters involved in emergency suppression of municipal structural fires are significantly exposed to combustion-derived carcinogens, i.e., PAH metabolites in urine.
- ✓ Results indicate/confirm that dermal contact is an important route of exposure.
- ✓ Dermal decontamination study indicates that dermal cleansing with soap and water can remove about ½ of deposited PAHs; level of urinary metabolites does not change.
- ✓ SWs useful tool for passive exposure monitoring at fire suppression scene. Non-invasive.
- ✓ GOC Firefighter Action Plan - numerous activities, including extensive literature review to assess state of knowledge about firefighters' exposures to toxicants of concern.
- ✓ Current CMP-funded work assessing exposures to chemical flame retardants and PFAS. Will provide information required to design a sound biomonitoring study.
- ✓ Ongoing work (i.e., CMP-funded Health Canada project, McGill collaboration, literature review) will provide foundational information that can be used to design and implement remedial measures to minimize exposures and associated health risks (e.g., improved PPE, new SOPs, etc.)