

Evaluating On-Scene Decontamination to Mitigate Firefighter Carcinogenic Exposure: Rationale and Prospective Study Design

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Firefighter Carcinogen Exposure Risks

- U.S. firefighters face a 25% higher cancer mortality compared to career professionals, yet under 5% perform full post-fire decontamination (Teras et al., 2025; Fernandez et al., 2023).

At the Fallen Fire Fighter Memorial, 79.4% of the members added to the memorial died of occupational cancer (IAFF, 2025).

Carcinogenic fire smoke risks in Texas firefighters are critically understudied.



Objectives and Specific Aims

This CPRIT study evaluates a **3-part toolkit** (gear washing, dermal wipes, and saline nasal swab) alongside real-time air and urinary biomonitoring to objectively demonstrate reductions in internal carcinogen dose in firefighters.

- Determine the effectiveness of decontamination for both immediate and sustained exposure reduction.
- Elucidate the connection between: exposure control, internal dose, and cancer risk mitigation in the fire service.

Specific 1 Quantify Inhalation Exposure (Personal Air Sampling + Mucosal Swabs; Baseline Profile)

Specific 2 Evaluate Acute Decon Efficacy (3-Part Protocol; Urinary PAH metabolites; Acute Dose Reduction vs. Routine Field Practices)

Specific 3 Track Longitudinal Risk (3-Year Track; Adherence Tracking ($\geq 70\%$ low vs $\leq 30\%$); Cumulative Exposure-Response Modeling)

Study Design and Field Operation

Fireground

Environmental Ambient Air + Baseline Personal Profile

- Integrated sensor suite (5700X, Kestrel Instruments, Boothwyn, PA)
- Real-time mass- and count-based particle measurements (DustTrak 8533 and NanoScan SMPS and OPS 3914, TSI Inc., Shoreview, MN)
- Personal breathing-zone impactor (Sioutas five-stage, SKC, Eighty-Four, PA)
- Mucosal swabs (DNA/RNA Shield Collection Tube w/ Swab, Zymo Research, Orange, CA)



Event 1: Pre-Intervention

Routine Decontamination

- Standard post-fire field practices
- Spot urine after 2 - 4h fire suppression

Event 2: Post-Intervention

Structured 3-Part Decon Toolkit

- Gross PPE washing + Dermal wipes + Sterile saline nasal swab cleaning
- Spot urine after 2 - 4h fire suppression

1. Gross PPE washing



2. Dermal wipes



3. Nasal Swab



Analysis - Acute Dose Quantification



- Swab PAH: N2 RapidVap (Labconco Corp, Kansas City, MO) + Triple Quadrupole GS-MS/MS (Agilent, Santa Clara, CA)
- Urinary PAH metabolites: Triple Quadrupole LC-MS/MS+ HPLC (Thermo Fisher Scientific, Waltham, MA).

3-Year Follow-Up Long-Term Influence

- Paired with HFD's annual occupational medical exam (Year 1 and 2)
- Spot urine
- Linear mixed-effects models (LMMs): baseline, follow-up Y1, and follow-up Y2.

Targeted Impacts

✓ Airborne & Inhaled PAH Profiles:

Correlating **size-fractionated airborne** particles (10 nm–10 μ m) with anterior nares deposition pre- and post-fire.

✓ Decontamination Efficacy:

Quantifying acute **post-fire reductions** from gross PPE cleaning, dermal wipes, and saline nasal swab.

✓ Longitudinal Biomarker Trajectories:

Evaluating 3-year cumulative internal PAH burden attenuation based on decontamination **adherence** ($\geq 70\%$ vs. $\leq 30\%$).

✓ Systemic Biological Responses:

Assessing PAH-driven shifts in complete **urinary metabolites** and **nasal microbiota diversity** (*Acinetobacter* abundance)

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