



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

WILDLAND & WUI EXPOSURES: DEVELOPING RESPIRATORY PROTECTION

Jeff Burgess, MD, MS, MPH

Professor, University of Arizona Zuckerman College of Public Health

Director, Fire Fighter Cancer Cohort Study

Email: jburgess@arizona.edu

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FIREFIGHTER OCCUPATIONAL EXPOSURE

- Exposures to multiple hazards
 - Smoke incl. polycyclic aromatic hydrocarbons (PAHs)
 - Per- and polyfluoroalkyl substances (PFAS)
 - Flame-retardants
 - Shiftwork/Heat exposure/Stress
- IARC Group 1 human carcinogens
 - Asbestos, benzene, benzo[a]pyrene, 1,3-butadiene, diesel exhaust, formaldehyde, dioxin, and more
- Wildland firefighters
 - Benzene, formaldehyde, and PAH exposures¹⁻⁴
 - ↑ carbon monoxide (CO) exposures⁵

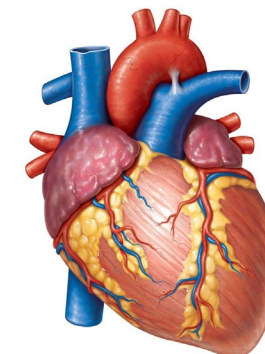
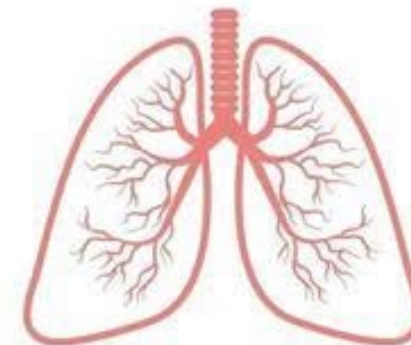
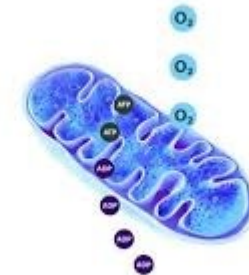


1. Ward and Hardy, 1991; 2. Reinhardt and Ottmar, 2004; 3. Broyles, 2013; 4. Robinson et al., 2008; 5. Semmens et al., 2021

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WILDLAND FIREFIGHTER HEALTH OUTCOMES

- Inflammation and oxidative stress after prescribed burns^{6,7} and wildfires⁸
- Changes in lung function
 - Cross-season¹⁻³
 - With firefighting activity⁴ and exposure to smoke⁵
- Hypertension and arrhythmias⁹
- Estimated increased risk of lung cancer mortality and cardiovascular disease¹⁰



1. Rothman et al., 1991; 2. Liu et al., 1992; 3. Gaughan et al., 2008; 4. Rothman et al., 1991; 5. Adetona et al., 2011; 6. Adetona AM et al., 2017; 7. Adetona et al., 2019; 8. Main et al., 2019; 9. Semmens et al., 2016; 10. Navarro et al., 2019



IARC MONOGRAPHS VOL. 132: OCCUPATIONAL EXPOSURE AS A FIREFIGHTER

Occupational exposure as a firefighter is **carcinogenic to humans (Group 1)** on the basis of **sufficient evidence for cancer in humans**



The *IARC Monographs* classification indicates the level of certainty that an agent can cause cancer (*hazard identification*)

Higher level of certainty Lower level of certainty



Cancer types with **sufficient evidence** for cancer in humans:



Mesothelioma Bladder cancer

Cancer types with **limited evidence** for cancer in humans:



Colon cancer Prostate cancer Testicular cancer Melanoma of the skin Non-Hodgkin lymphoma

Strong mechanistic evidence in exposed firefighters



Exposures of firefighters include combustion products, diesel exhaust, building materials, asbestos, chemicals, shift work, ultraviolet radiation



Firefighters respond to various types of fire



Structure



Wildland



Vehicle



FIRE FIGHTER CANCER COHORT STUDY (FFCCS)

Mission: To conduct community-engaged research with the fire service to advance firefighter cancer control and prevention, as well as evaluation and prevention of other health conditions

Goal: To enroll 10,000 firefighters and follow them over 30 years

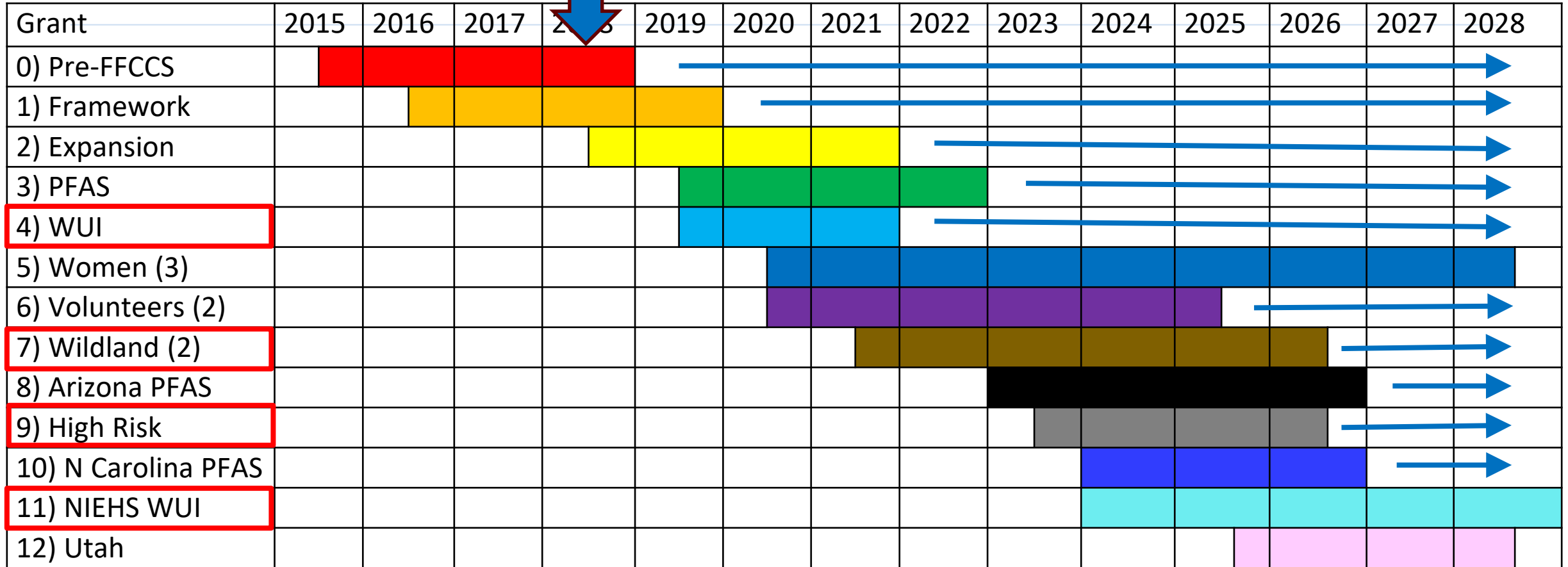
Biological samples: Collected at study enrollment, every two years, and after specified exposures, analyzed for exposures and toxic effects



Established 2016



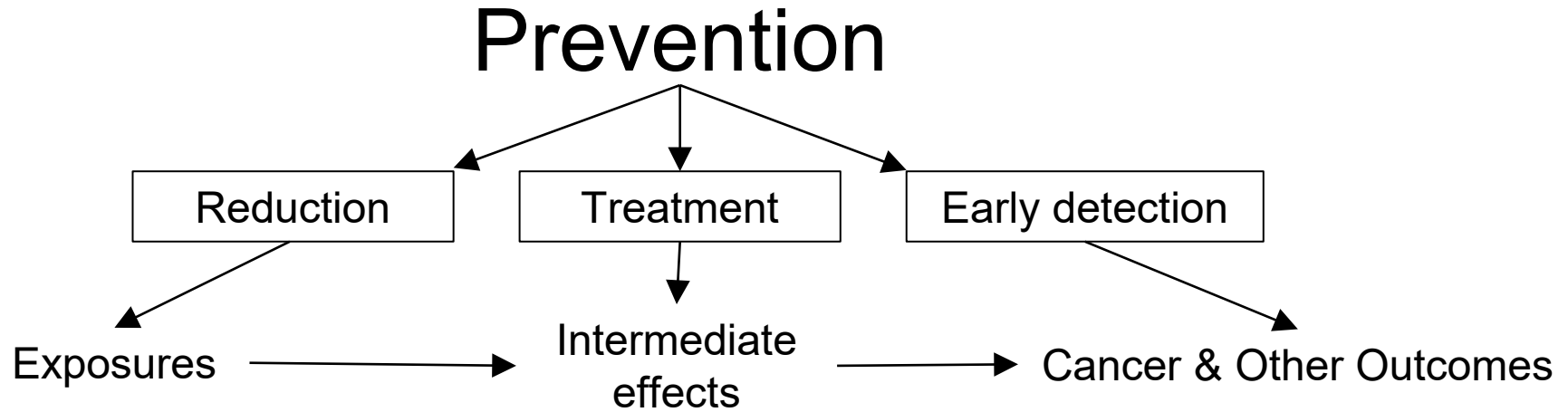
FFCCS PROJECTS



Funding: **FEMA** EMW-2014-FP-00200, EMW-2015-FP-00213, EMW-2017-FP-00860, EMW-2018-FP-00086, EMW-2019-FP-00526, EMW-2019-FP-00517; EMW-2020-FP-00430; EMW-2021-FP-00141; EMW-2021-FP-00416; EMW-2022-FP-00774; EMW-2022-FP-00711; EMW-2024-FP-00711; **NIEHS** P30 ES006694, P30 ES017885; R01 ES035965; **NIOSH**; **IAFF**; **Fire Departments**; **Arizona Board of Regents**; **State of North Carolina**, **State of Utah**



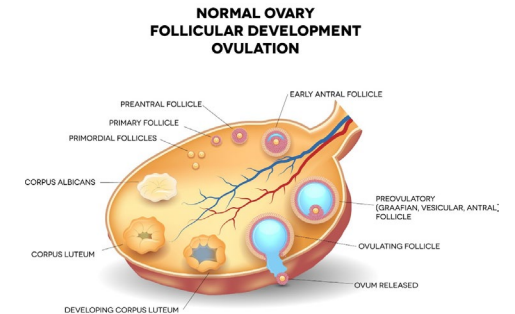
FFCCS RESEARCH CONCEPTS



Improved respirator use,
dermal decontamination, etc.



Lifestyle, diet, Rx, etc.



Reproductive reserve, etc



BIOMARKERS OF EXPOSURE AND WRISTBANDS

Urine

- Used to measure hydroxylated metabolites of polycyclic aromatic hydrocarbons (PAH-OHs)
- Reflects combined inhalation and dermal exposures
- Proxy for exposure to other unmeasured chemicals



Both reported back to firefighter participants

Silicone wristbands

- Used to measure PAHs and 100's of other chemicals
- Reflects chemical exposures in air and deposited on skin
- Must be worn for entire fire shift or multiple days



WILDLAND FIREFIGHTER INITIAL RESULTS

- >700 participants across California, Colorado, Utah, and Wyoming
- Analysis of the first ~300 post-fire urine samples compared to their pre-fire baselines
- **Average PAH-OH exposures were WUI > prescribed > wildland fires**

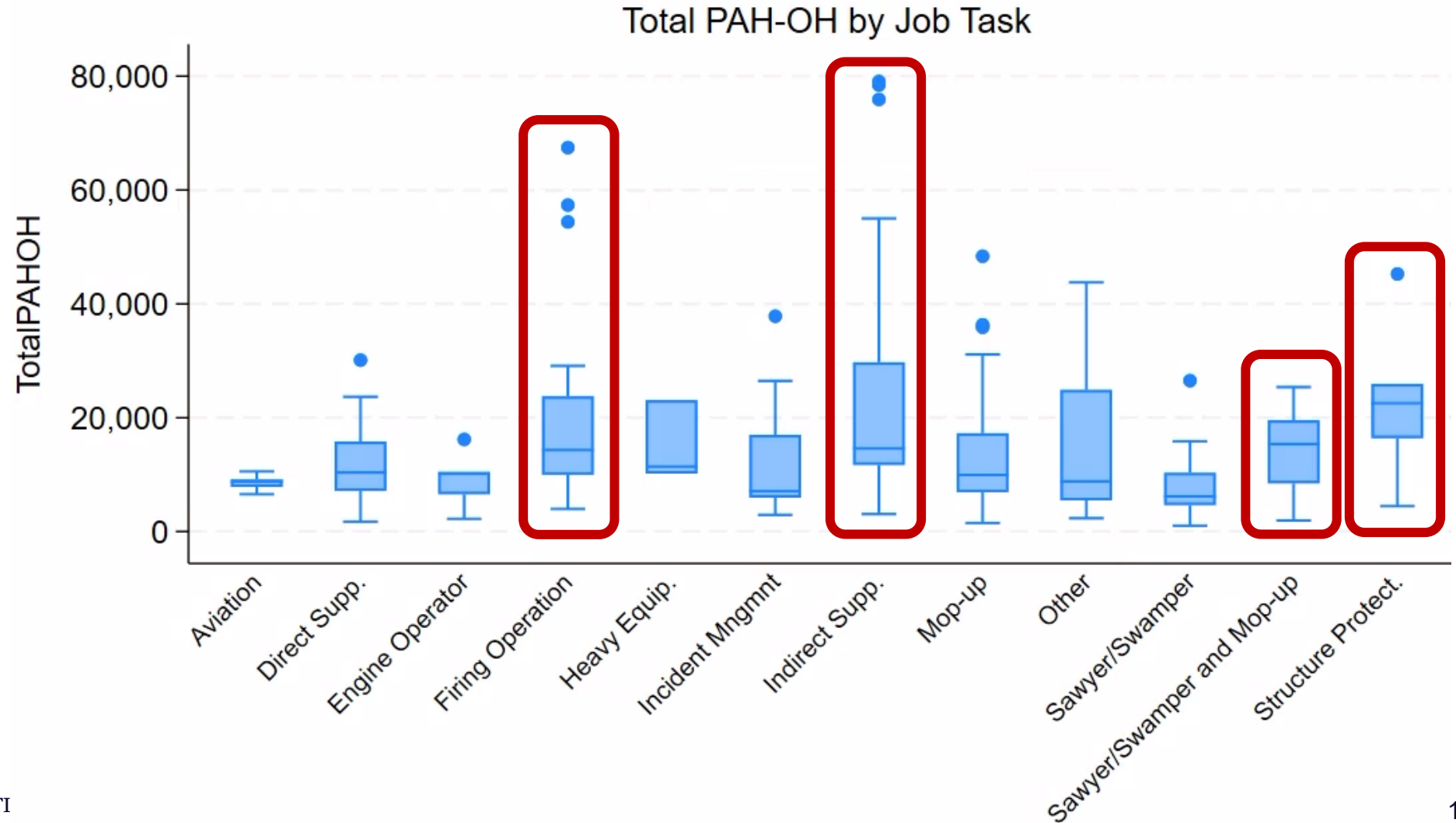
Fire Type	Mean (ng/g Cr)	Standard Deviation (ng/g Cr)	Frequency (N)
WUI	16,369	12,275	19
Prescribed Fire	12,243	12,219	47
Wildland	11,096	13,417	157
Total	11,636	12,743	223



WILDLAND FF EXPOSURES BY JOB TASK

Highest exposures:

- Firing operation
- Indirect suppression
- Sawyer/swamper & mop-up
- Structure protection



“CLEAN GEAR FOR A LONG CAREER”

- **A 37% reduction in total urinary PAH metabolites** when wearing gear laundered since the last exposure
- **Silicone wristbands also showed reduced exposure** to multiple chemicals in individuals wearing laundered gear, including:
 - **Combustion byproducts (↓ 50-60%)**
 - **Brominated flame retardants (↓ 30-50%)**
 - **A chlorinated flame retardant (↓ 70%)**

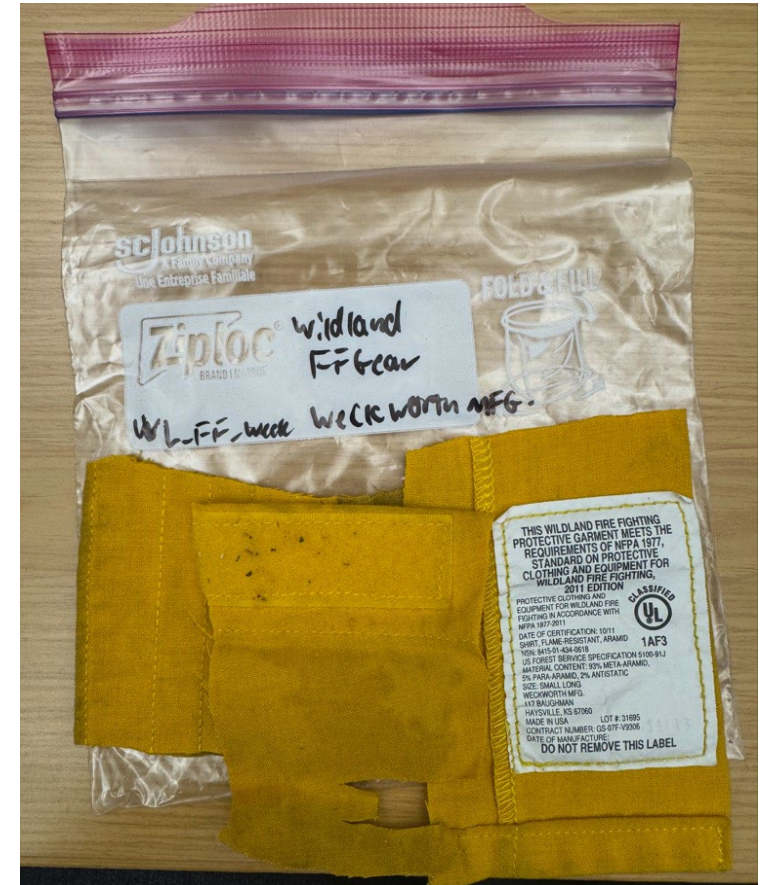


<https://dribbble.com/shots/14223214-Washing-machine-cartoon-illustration-vector>



WILDLAND GEAR ANALYSIS

- Three wildland coat textile samples manufactured between 2004-2011
- No PFAS detected
- Brominated flame retardants (BFRs) detected in all three samples
- Measured levels do not indicate intentional application; likely contamination from soot/smoke exposure



LA URBAN CONFLAGRATIONS

- FFCCS collaborating with multiple area fire depts
- Collected silicone wristbands worn during the fires and urine samples collected immediately afterwards
- Followed-up or enrolled >600 LA area firefighters after the fires (January-March)
 - Including firefighters who responded to the fires and a comparison group not involved in the fire response
- >120 of these firefighters also provided blood samples in 2024 prior to the fires
 - Provides an opportunity to measure pre-post exposure changes in biomarkers of cancer and other disease risk
- We report back results as they become available



Palisades Fire (courtesy of Oxnard Fire Department)

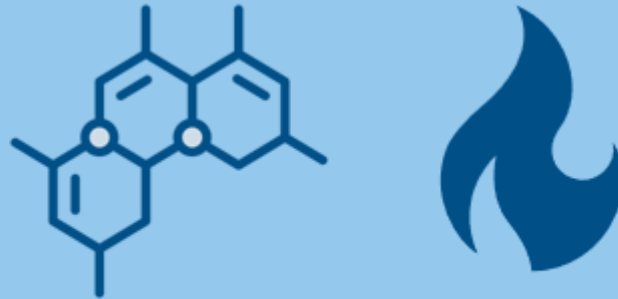


Palisades Fire aftermath (courtesy of UA research team)



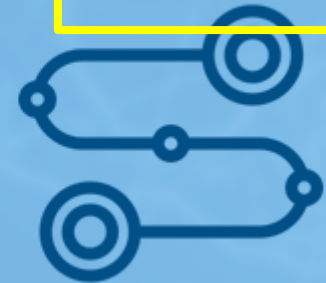
How did serum proteins change in firefighters responding to the Los Angeles area urban conflagration fires?

Serum proteins were analyzed in blood collected from 42 firefighters before and after responding to the urban conflagrations.



Sixty proteins associated with nucleotide synthesis and repair, oxidative stress response, energy metabolism, or other mechanisms changed significantly from before to after exposure.

Protein pathway analysis identified changes in metabolism and oxidative stress, immune and inflammatory responses, cellular barrier integrity and trafficking, and growth/cancer signaling.



Changes in Serum Proteins in Firefighters Responding to the 2025 Los Angeles Urban Conflagrations, Melissa Furlong, PhD, Shawn C. Beitel, MS, Reagan Conner, MPH, Jaclyn M. Goodrich, PhD, Xinxin Ding, PhD, Matt Rahn, PhD, MS, Kelcey Stricker, DrPH, Aaron Guggenheim, MPH, Alexander Hamilton, Derek Biering, Jeff Hughes, John J. Gulotta, Cynthia Porter, MS, James Hollister, MS, Jefferey L. Burgess, MD, MS, MPH

A CAUTIONARY TALE

- Study objective: to evaluate the effectiveness of air purifying respirators (APRs) during overhaul compared with no APR
- FD-A wore no respiratory protection and FD-B wore APRs
 - CC16 and SP-A are serum pneumoproteins
 - FEV₁: forced expiratory volume in one second
 - FVC: forced vital capacity; -OH: after overhaul

Group	n	CC16	SP-A	n	FVC (L)	FEV ₁ (L)
A	25	8.9±3.5	287±144	19	5.42±0.72	4.10±0.62
A-OH	25	12.3±3.6	306±157	19	5.36±0.73	3.94±0.65
B	26	9.6±3.5	250±117	26	5.44±0.68	4.22±0.51
B-OH	26	14.6±5.2	334±141	26	5.29±0.74	4.09±0.56

- FD-B had poorer respiratory outcomes despite APR use



THERE IS NO 'SMOKE' CARTRIDGE

- For certification by NIOSH, cartridges and canisters are tested against individual chemicals
- We tested them against smoke
- **General multipurpose APR cartridges showed formaldehyde breakthrough**
- Chemical, biological, radiological and nuclear (CBRN) cartridges and canisters were more effective for formaldehyde and other chemicals (except CO)



Jones L, Lutz EA, Duncan M, Burgess JL. Respiratory protection for firefighters--evaluation of CBRN canisters for use during overhaul. J Occup Environ Hyg. 2015;12(5):314-22.



AUSTRALIAN BUSHFIRE APR USE

- Australia-US Fulbright Program 2023
- Disposable particulate respirators often used
- Silicone half- or full-face respirators widely available
- Carbon monoxide (CO) monitoring used in some states to help identify high exposure settings and inform administrative controls



CANADIAN WILDLAND FIREFIGHTER RESEARCH

- Alberta & British Columbia FFs responding to prescribed burns, hot spotting after a major fire in a coniferous forest, and containing active fires¹
- **↓ urinary 1-HP in FFs encouraged to shower and change into clean clothes ASAP** (if PAHs on end-of-shift hand wipe)
- Cleanshaven FFs wearing disposable N95 or P100 organic vapor cartridge half facepiece mask >90% of the time had >50% ↓ in 1-HP
- **In follow-on study, ↓ APR effectiveness with ↓ % time used and with beards²**

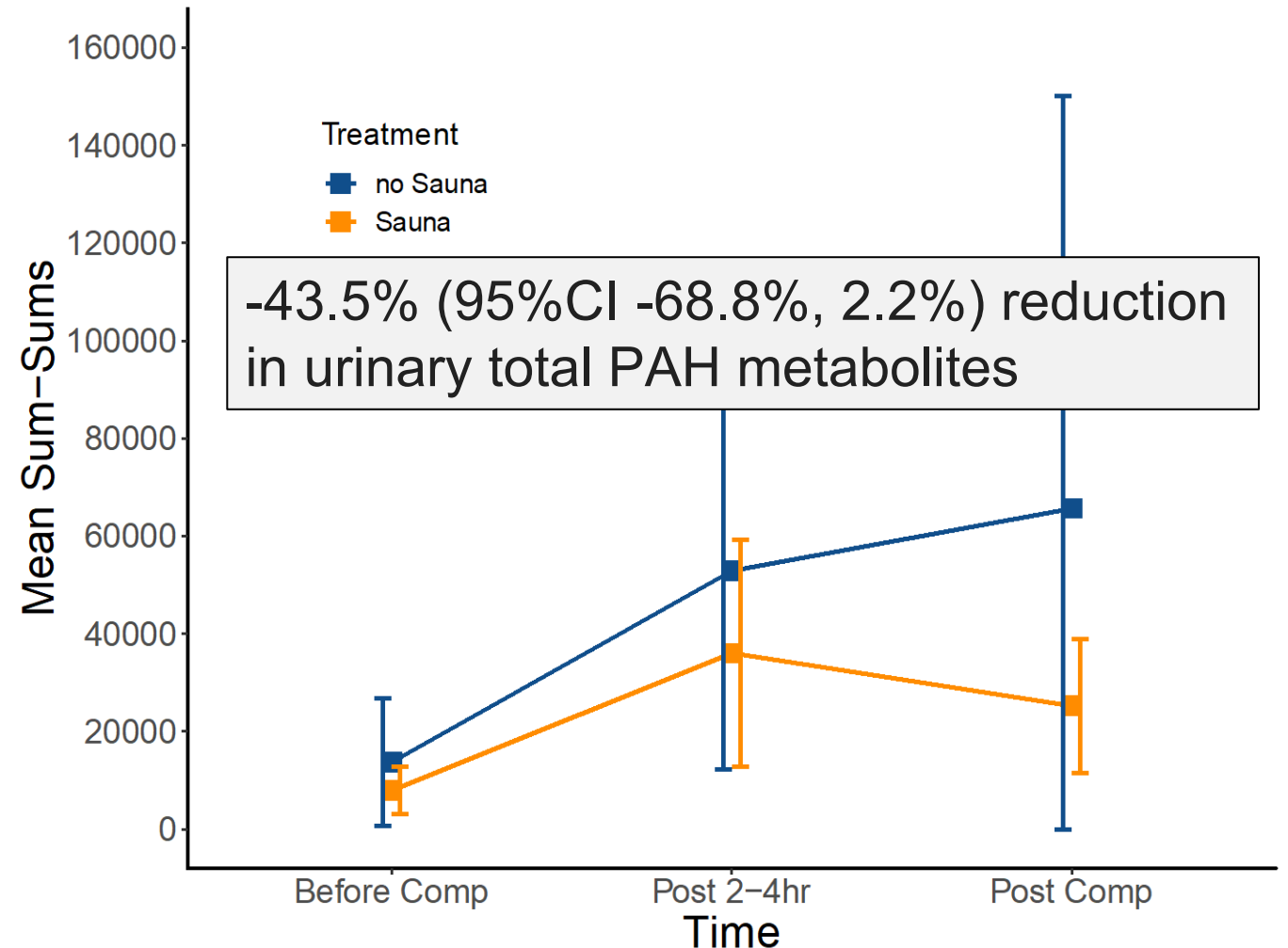


1. Cherry et al., Exposure and Absorption of PAHs in Wildland Firefighters: A Field Study with Pilot Interventions. Ann Work Expo Health. 2021 Mar 3;65(2):148-161. 2. Broznitsky et al. A field investigation of 3 masks proposed as respiratory protection for wildland firefighters: a randomized controlled trial in British Columbia, Canada. Ann Work Expo Health. 2024 Nov 25;68(9):906-918.

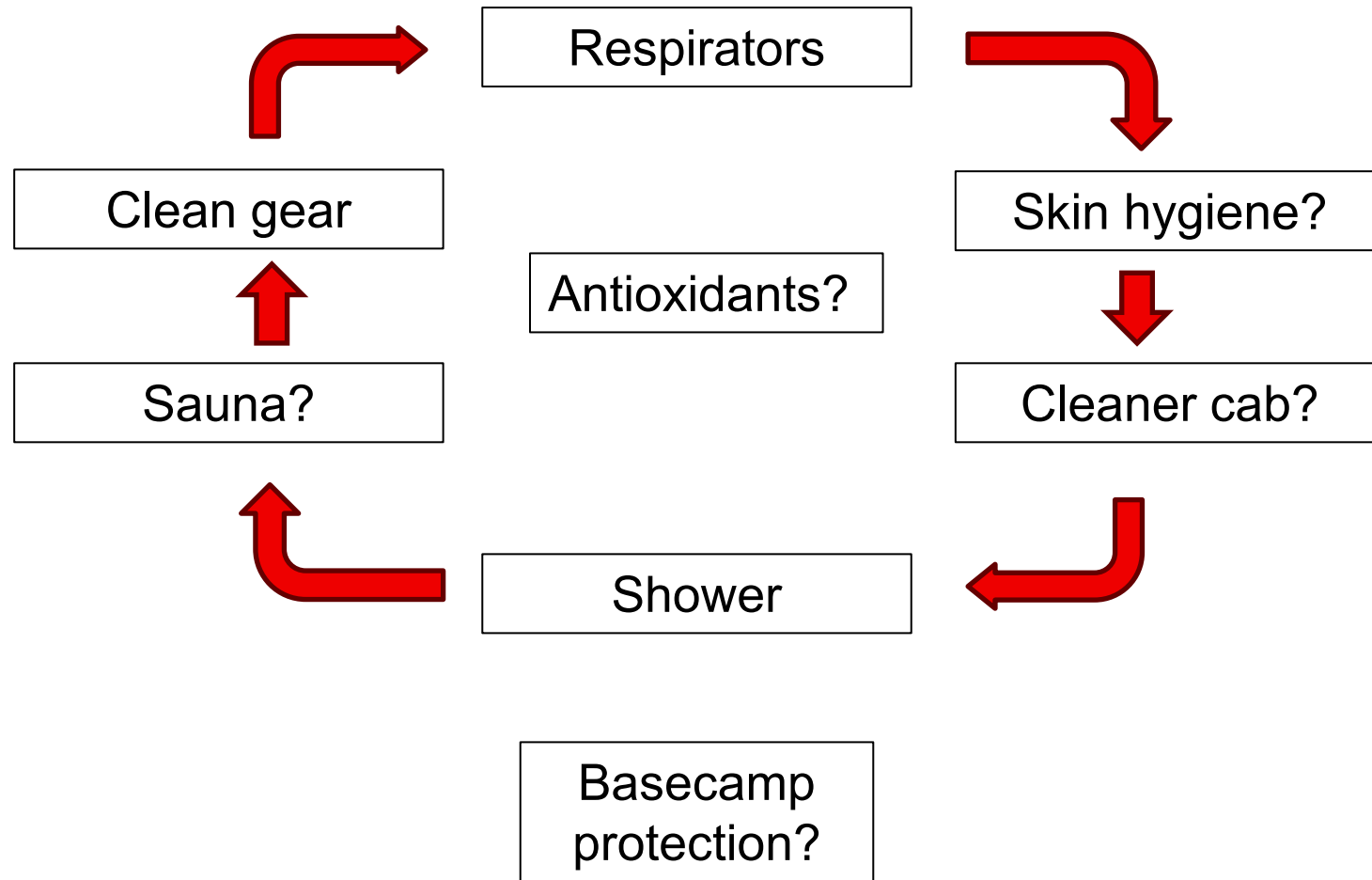


SAUNA STUDY

- Local 5050/Scottsdale Fire Dept
- Two training evolutions & rehab followed by shower (n= 24 FF)
- Half randomized to infrared sauna x 20 min @ 120°F (no exercise) then shower



MULTIPLE INTERVENTIONS WILL LIKELY BE NEEDED



NEXT STEPS

Additional Wildland FF studies

- Evaluate chronic toxicity
- Total antioxidant capacity (pilot)
- Potential intervention tests:
 - Respiratory protection
 - Clean cab
 - Dermal contamination reduction
 - Skin wipes
 - Gear laundering
 - Sauna
 - Skin barrier cream



Additional LA/WUI Studies

- Updated serum PFAS, silicone wristband, and urine metabolomic analyses coming soon
- Urine metals already reported back
- Measurement of toxic effects ongoing
- Measurement of antioxidant capacity coming soon
- Planning for future intervention studies



Wildland Respiratory Protection Equipment Development Project



Collaborative effort to develop **EFFECTIVE & PRACTICAL** respiratory protection for use by wildland and WUI firefighters

Currently evaluating feasibility and acceptability of prototype devices in multiple work settings (e.g. holding, structure defense, etc.)

ACKNOWLEDGEMENTS

Study teams at:

- University of Arizona
- Colorado State University
- Duke University
- NIOSH
- University of Michigan
- Wildfire Conservancy
- **Fire service research liaisons/champions**
- Multiple fire departments and IAFF locals
- IAFF
- FCSN
- NVFC
- Metro Chiefs
- Women in Fire
- Others

Funding: **FEMA, NIOSH, and NIH**

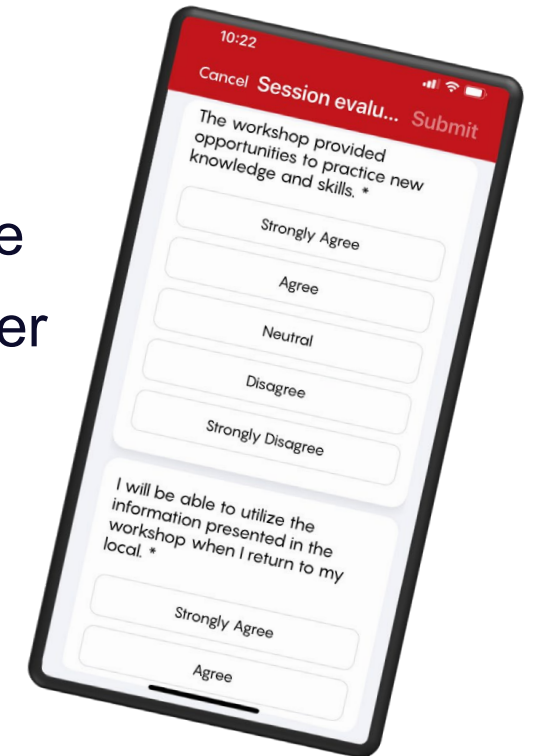




THANK YOU!
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- **Complete your evaluations using the IAFF app:**
 1. Download the IAFF app and sign in with your iaff.org username
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 3. Tap "Sessions" and tap on the workshops you attended
 4. Tap "Evaluation" and complete the evaluation
 5. Tap "Submit"



For the event's overall evaluation, follow steps 1 and 2, then tap "Event Evaluation" located in the event's Dashboard.

