Research Institutes | Chemical Insights

TECHNICAL BRIEF

A Strategic Research Initiative on the Cardiopulmonary Detriments of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Exposure in Firehouses

Chemical Insights Research Institute (CIRI) is characterizing PFAS from exposure scenarios specific to firehouses and determining their cardiopulmonary health implications.

Introduction

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a class of fluorinated aliphatic compounds commonly used in consumer and industry products because of their resistance to heat and their unique surfactant qualities. PFAS are ubiquitously found in household and occupational settings as well as in the environment. The pervasive and persistent nature of PFAS allows for accumulation within the environment and the exceptionally long half-life (2-9 years in people) allows for bioaccumulation within human tissue.[1] Exposure routes include inhalation through environmental exposures, dermal exposure from textiles, and ingestion through potable water, contaminated food, and food packaging.

Firefighters undergo significant PFAS exposure as they are commonly found in aqueous film forming foams,[2] emissions and dust from the burning built environment,[3] and are used as a fire suppressant and as resistant coatings in their turnout gear.[4] As such, community-based firefighters have been found to have higher circulating levels of PFAS compared to the public.[5,6] Studies have evaluated the levels of PFAS in the blood serum of firefighters with differential results dependent on geographical location and exposure scenario. For example, perfluorohexanesulfonic acid (PFHxS) was elevated in National Health and Nutrition Examination Survey (NHANES) data in both an Australian firefighter cohort[7] and an Arizona firefighter cohort.[8] Other studies have demonstrated serum concentrations of legacy PFAS (e.g., perfluorooctanoate [PFOA] and perfluorooctane sulfonate [PFOS]) and PFHxS ranging from 18 percent to 74 percent higher than the general population.[9]

Governmental agencies, including the United States Environmental Protection Agency (EPA) and National Institute of Occupational Safety and Health (NIOSH), have associated PFAS exposure levels with poor health outcomes.[10,11] More specifically, PFAS have been associated with higher risk of cardiovascular disease (CVD).[12] It is well established that firefighters are at higher risk for certain conditions, including various cancer types[11] and CVD.[13,14] While firefighter PFAS exposure in the context of certain cancers has been well investigated, it is less understood how PFAS exposure, especially newly emerging PFAS, may contribute to CVD in this population.

Study Objectives

The purpose of this study is to further characterize firefighter legacy and emerging PFAS exposure, determine firehouse PFAS exposure pathways, and evaluate how these exposure scenarios contribute to PFAS-driven cardiopulmonary conditions.

SPECIFIC OBJECTIVES INCLUDE:

1. Characterization of PFAS exposure scenarios existing in local firehouses (fire stations).
2. Determination of cardiopulmonary health implications of these exposures at the molecular and functional levels.

Study Plan Overview

Study objectives will be met through environmental sampling and analysis to evaluate PFAS exposure levels in air and dust. Specific firefighter health studies will be conducted to determine the impact of these exposures on cardiopulmonary dysfunction.

ENVIRONMENTAL EXPOSURE ASSESSMENT PLAN:

1. Indoor active air sampling will take place inside the fire station to quantify PFAS inhalation exposures that exist in this occupational environment during normal occupancy.
2. Settled dust will be collected from various regions of the fire station and occupational vehicles of firefighters to evaluate PFAS exposure that may occur due to deposition and accumulation within settled dust as a result of typical work conditions.

FIREFIGHTER HEALTH ASSESSMENT PLAN:

1. Firefighters of various ages, sex, and tenure will be recruited from fire stations throughout the metro Atlanta area (n≈100). Enrolled firefighters will complete a survey regarding their career history, health and medical history, lifestyle habits, and other factors. Anthropometric and hemodynamic measures will be obtained from enrolled individuals.
2. Biospecimens, including whole blood and saliva, will be collected from firefighters to evaluate PFAS levels, markers of oxidative stress and inflammation, and markers of vascular and respiratory injury in the serum and saliva, respectively.
3. Functional parameters of cardiopulmonary dysfunction, including flow-mediated dilation for endothelial function and spirometry for lung pulmonary function, will be measured to associate exposure levels with changes in functional measures.
4. To gain a further understanding of the impacts of PFAS at the cellular level, laboratory studies will be conducted with collected dust. The dust will be re-aerosolized and exposed to small airway epithelial cells (SAEC) at the air liquid-interface. Furthermore, media collected, likely containing PFAS and cellular mediators released from SAEC, will be applied to human coronary artery endothelial cells (HCAEC) to gain a greater understanding of the interaction between PFAS exposure and the cardiopulmonary systems.

Scientific Outcomes

1. Characterization of PFAS exposure associated with fire station environments.
2. Correlation of PFAS exposure with alterations in cardiopulmonary functioning in firefighters.
3. Expanded knowledge base of the molecular implications of PFAS exposure.

Future work

The goal of this study will be to develop a guidance document that aims to address and mitigate potential PFAS exposure to firefighters resulting from fire station environments. Furthermore, this study will provide a general understanding of the effects of PFAS exposure in an extreme scenario and allow for future investigation of exposures in the general population.

References

1. Sunderland EM, Hu XC, Dassuncao C, Tokranov AK, Wagner CC, Allen JG. A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects. *J Expo Sci Environ Epidemiol*. **2019**;29:131-147. https://www.doi.org/10.1038/s41370-018-0094-1.

2. Place BJ, Field JA. Identification of novel fluorochemicals in aqueous film-forming foams used by the US military. *Environ Sci Technol*. **2012**;46:7120-7127. https://www.doi.org/10.1021/es301465n.

3. Ellis DA, Mabury SA, Martin JW, Muir DC. Thermolysis of fluoropolymers as a potential source of halogenated organic acids in the environment. *Nature*. **2001**;412:321-324. https://www.doi.org/10.1038/35085548.

4. Peaslee GF, Wilkinson JT, McGuinness SR, Tighe M, Caterisano N, Lee S, Gonzales A, Roddy M, Mills S, Mitchell K. Another Pathway for Firefighter Exposure to Per- and Polyfluoroalkyl Substances: Firefighter Textiles. *Environ Sci Technol Lett*. **2020**;7;594–599. https://www.doi.org/10.1021/acs.estlett.0c00410.

5. Lucas K, Gaines LGT, Paris-Davila T, Nylander-French LA. Occupational exposure and serum levels of per- and polyfluoroalkyl substances (PFAS): A review. *Am J Ind Med*. **2023**;66:379-392. https://www.doi.org/10.1002/ajim.23454.

6. Goodrich JM, Calkins MM, Caban-Martinez AJ, et al. Per- and Polyfluoroalkyl Substances, Epigenetic Age and DNA Methylation: A Cross-Sectional Study of Firefighters. *Epigenomics*. **2021**;13:1619-1636. https://www.doi.org/10.2217/epi-2021-0225.

7. Rotander A, Toms L-ML, Aylward L, Kay M, Mueller JF. Elevated levels of PFOS and PFHxS in firefighters exposed to aqueous film forming foam (AFFF). *Environ Int*. **2015**;82:28-34. https://doi.org/10.1016/j.envint.2015.05.005.

8. Khalil N, Ducatman AM, Sinari S, Billheimer D, Hu C, Littau S, Burgess JL. Per- and Polyfluoroalkyl Substance and Cardio Metabolic Markers in Firefighters. *J Occup Environ Med*. **2020**;62:1076-1081. https://www.doi.org/10.1097/jom.0000000000002062.

9. Leary DB, Takazawa M, Kannan K, Khalil N. Perfluoroalkyl Substances and Metabolic Syndrome in Firefighters: A Pilot Study. *J Occup Environ Med*. **2020**;62:52-57. https://www.doi.org/10.1097/jom.0000000000001756.

10. United States Environmental Protection Agency. Our Current Understanding of the Human Health and Environmental Risks of PFAS, https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas (2024).

11. Daniels RD, Kubale TL, Yiin JH, Dahm MM, Hales TR, Baris D, Zahm SH, Beaumont JJ, Waters KM, Pinkerton LE. Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950-2009). *Occup Environ Med*. **2014**;71:388-397. https://www.doi.org/10.1136/oemed-2013-101662.

12. Meneguzzi A, Fava C, Castelli M, Minuz P. Exposure to Perfluoroalkyl Chemicals and Cardiovascular Disease: Experimental and Epidemiological Evidence. *Front Endocrinol (Lausanne)*. **2021**;12:706352. https://www.doi.org/10.3389/fendo.2021.706352.

13. Burris JC, Werner CM, Woolf K. The Relationship Between Dietary Intake and Dietary-Focused Lifestyle Interventions on Risk Factors Associated with Cardiovascular Disease in Firefighters. *Curr Nutr Rep*. **2022**;11:206-224. https://www.doi.org/10.1007/s13668-022-00406-3.

14. Pendergrast C, Boyle T, Crockett AJ, Eston R, Johnston KN. Longitudinal lung function in urban firefighters: A group-based multi-trajectory modelling approach. *Respirology*. **2023**;28:247-253. https://www.doi.org/10.1111/resp.14382.

2211 Newmarket Parkway, Suite 106, Marietta, Georgia 30067 | chemicalinsights.org | chemicalinsights@ul.org