

Association of Per- and Polyfluoroalkyl Substances (PFAS) Exposure with Cognitive Function in Firefighters

P4-13

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Preliminary results revealed that PFOS was the primary contributor among the PFAS mixture (consisting of PFOS, PFOA, PFHxS, PFHpA, PFNA, and PFDA) linked to reduced processing speed scores in firefighters. While longitudinal studies are needed to assess cognitive health in relation to PFAS exposure, these data could inform analyses in support of workplace exposure reduction efforts and revision of preventive health care for first responders.

INTRODUCTION

Per- and polyfluoroalkyl substances (PFAS), or “forever chemicals,” are persistent compounds that accumulate in the human body and are linked to adverse health outcomes, including cancer, immune suppression, thyroid dysfunction, metabolic disruption, and neurodevelopmental effects.¹⁻⁴ Firefighters are at elevated risk of PFAS exposure due to their presence in turnout gear, training environments, and firefighting foams such as aqueous film-forming foam (AFFF), with exposure occurring through inhalation, dermal contact, and hand-to-mouth transfer.^{2,5,6} Biomonitoring studies have reported higher serum PFAS levels in firefighters compared to the general population, likely due to occupational sources. Additionally, firefighters face chronic occupational stressors—such as shift work, sleep disruption, and hazardous exposures—that may contribute to both short- and long-term mental health impairment.⁶⁻⁸

METHODS

Participants were 65 active firefighters from four Central Texas cities who provided complete data June 2023–March 2025. Global cognition and processing speed were assessed with the NIH Toolbox Cognition Battery and standardized to z-scores. Whole blood concentrations of 24 PFAS were measured by liquid chromatography-tandem mass spectrometry and log-transformed; six PFAS (PFHxS, PFHpA, PFOA, PFOS, PFNA, PFDA) with detection frequencies >70% and U.S. comparison data (NHANES 2013–2014) were selected as primary exposures. Covariates included sociodemographic, behavioral, health, and occupational factors (e.g., years of service, foam use, hygiene practices, and self-contained breathing apparatus use). Associations of individual PFAS and PFAS mixtures with cognitive performance were estimated using sequential linear regression, quantile g-computation, and Bayesian kernel machine regression.

RESULTS

	Global cognition β (95% CI)	P value	Processing speed β (95% CI)	P value
PFOS				
Model 1	-0.13(-0.42 to 0.16)	0.38	-0.13(-0.42 to 0.16)	0.22
Model 2	-0.27(-0.62 to 0.08)	0.13	-0.38(-0.76 to -0.003)	0.048
Model 3	-0.36(-0.72 to -0.01)	0.05	-0.58(-0.91 to -0.24)	<0.001
PFOA				
Model 1	0.03(-0.34 to 0.40)	0.89	0.20(-0.19 to 0.60)	0.32
Model 2	0.16(-0.25 to 0.57)	0.45	0.21(-0.25 to 0.65)	0.35
Model 3	0.12(-0.30 to 0.54)	0.58	0.06(-0.36 to 0.47)	0.78
PFHpA				
Model 1	-0.15(-0.42 to 0.12)	0.27	-0.12(-0.41 to 0.18)	0.44
Model 2	-0.20(-0.49 to 0.09)	0.17	-0.15(-0.46 to 0.16)	0.35
Model 3	-0.22(-0.50 to 0.07)	0.14	-0.16(-0.45 to 0.12)	0.27
PFNA				
Model 1	-0.04(-0.28 to 0.19)	0.72	0.11(-0.14 to 0.37)	0.37
Model 2	-0.06(-0.31 to 0.19)	0.63	0.19(-0.08 to 0.46)	0.16
Model 3	-0.13(-0.40 to 0.13)	0.33	0.06(-0.20 to 0.33)	0.63
PFDA				
Model 1	-0.04(-0.18 to 0.09)	0.52	-0.10(-0.24 to 0.05)	0.19
Model 2	-0.01(-0.15 to 0.13)	0.88	-0.10(-0.25 to 0.05)	0.18
Model 3	-0.004(-0.15 to 0.14)	0.96	-0.08(-0.22 to 0.06)	0.28
PFHxS				
Model 1	-0.12(-0.40 to 0.16)	0.40	0.10(-0.21 to 0.40)	0.53
Model 2	-0.16(-0.47 to 0.15)	0.32	0.06(-0.28 to 0.40)	0.72
Model 3	-0.20(-0.53 to 0.12)	0.22	-0.05(-0.38 to 0.27)	0.75
24-PFAS mixture				
Model 1	0.34(-0.06 to 0.74)	0.10	0.72(0.30-1.15)	0.10
Model 2	0.16(-0.28 to 0.60)	0.49	0.55(0.09-1.01)	0.02
Model 3	0.16(-0.31 to -0.66)	0.50	0.62(-0.04 to 0.87)	0.08

^a Model 1: unadjusted model. ^b Model 2: Model 1 + age, race/ethnicity, education, annual individual income, smoking history, number of past and current alcohol consumption, frequency of seafood consumption, and depressive symptoms. ^c Model 3: Model 2 + occupational characteristics: years of service, frequency of showers, frequency of firefighting foam utilization, and use of self-contained breathing apparatus (SCBA).
PFOS: perfluorooctanesulfonic acid; PFOA: perfluorooctanoic acid; PFHpA: perfluorooctanesulfonic acid; PFHxS: perfluorohexanesulfonic acid; PFNA: perfluorononanoic acid; PFDA: perfluorodecanoic acid.

BKMR	Processing speed			Global cognition		
	PIPs	X ^a	r (overall acceptance rate)	PIPs	λ	r (overall acceptance rate)
PFOS	0.80	0.34	0.34	0.21	0.21	0.37
PFOA	0.44			0.39		
PFNA	0.33			0.35		
PFDA	0.20			0.23		
PFHpA	0.33			0.41		
PFHxS	0.32			0.37		

	Posterior mean estimates	SD	Posterior mean estimates	SD
95% CI ^a	-0.65 to -0.12		-0.57 to 0.11	
Quantile	25th: 0.13	0.14	0.12	0.12
	75th: -0.14	0.13	-0.11	0.12

^a λ: the variance component (or signal variance) in the Gaussian kernel that defines the exposure-outcome function h(λ), estimated via the Markov Chain Monte Carlo (MCMC) sampling process. ^b 95% CI: 95% confidence interval from the posterior distribution to quantify uncertainty and assess (e.g., the change in outcome when exposure shifts from the 25th to the 75th percentile) the significance of mixture exposure-outcome association. Significant 95% CI should not include 0.
BKMR: Bayesian Kernel Machine Regression; PIPs: posterior inclusion probabilities; PFOS: perfluorooctanesulfonic acid (or perfluorooctanoic acid); PFOA: perfluorooctanoic acid; PFHpA: perfluorooctanesulfonic acid; PFHxS: perfluorohexanesulfonic acid; PFNA: perfluorononanoic acid; PFDA: perfluorodecanoic acid.
SD: posterior standard deviation.

CONCLUSIONS

PFOS showed a moderate-to-large adverse association with processing speed, indicating that even low PFAS levels (<1 pg/μL) may impair rapid information processing critical for firefighting performance. The stronger associations in fully adjusted models highlight the need to account for occupational factors; and suggest PFOS is the predominant driver within the PFAS mixture, while null findings for other domains and mixtures may reflect the dominant influence of this legacy PFAS and low detection of alternative PFAS.

Limitations: The lack of association between PFAS exposure and global cognition may partly reflect the healthy worker effect and the limitations of a small cross-sectional sample. Interpretation is further constrained by the absence of detectable gender or race/ethnicity differences and the potential for residual confounding from unmeasured factors.

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