



NAVY AND MARINE CORPS FORCE HEALTH PROTECTION COMMAND
IMPROVING READINESS THROUGH PUBLIC HEALTH ACTION

An Evaluation of the Relationship Between Firefighter Blood PFAS Levels, Age, and Sex in FY21-22

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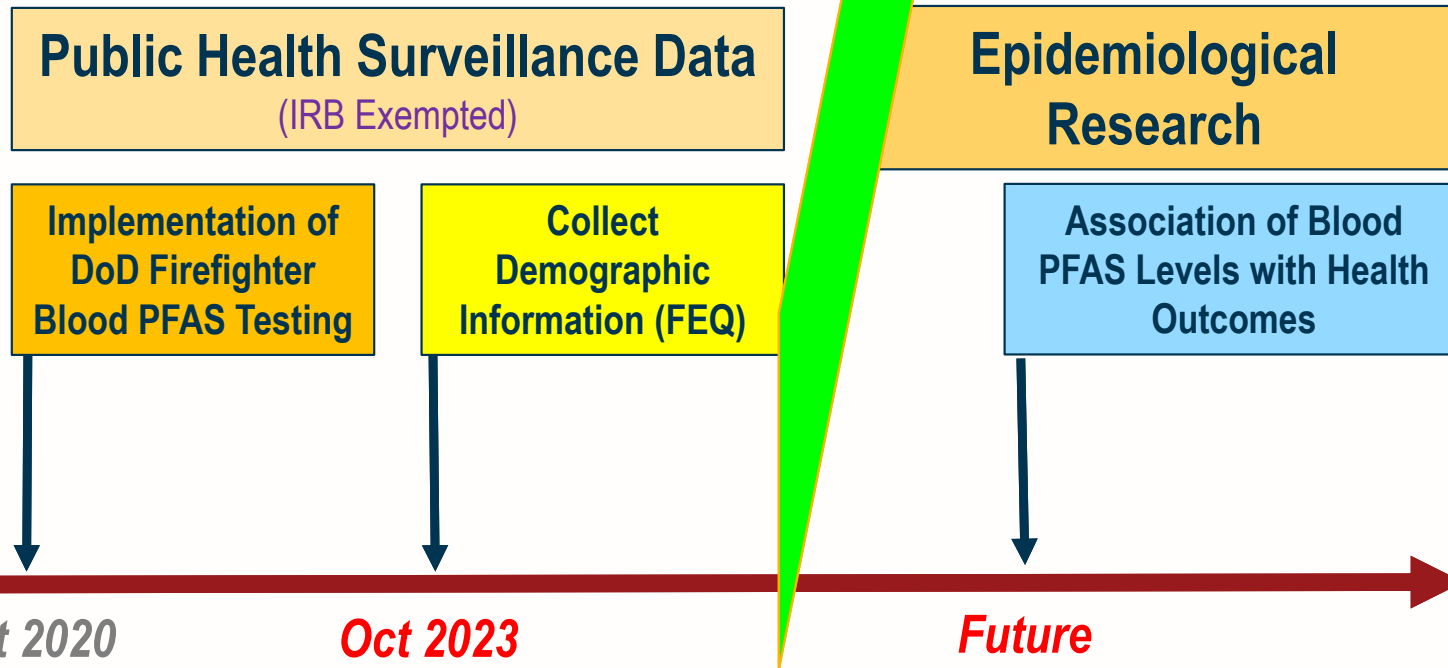
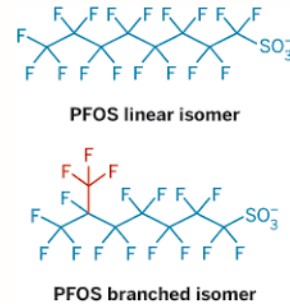
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Study Design: A Phased Approach to Track, Trend, and Analyze Firefighter Blood PFAS Test Results



PFAS = Per- and Polyfluoroalkyl Substances. IRB = Institutional Review Board. FEQ = Firefighter Exposure Questionnaire. DoD = Department of Defense.



EDC Analysis of Blood PFAS Data

Methodology:

- DoD offered annual blood PFAS testing to firefighters beginning in October 2020.
 - ✓ Analytical results appended to firefighter's medical record.
- Blood samples analyzed by CLIA certified clinical laboratory for 6 PFAS:
 - ✓ PFBS, PFHpA, PFHxS, PFNA and linear isomers of PFOA and PFOS.
- EDC queries CHCS and MHS GENESIS laboratory databases for:
 - ✓ Firefighter blood PFAS analytical data,
 - ✓ Age (date of birth), and
 - ✓ Sex (male or female).
- EDC summarizes firefighter blood PFAS analytical results:
 - ✓ Using univariate statistics in the same manner as the CDC does in NHANES.

CDC = Centers for Disease Control and Prevention.

CHCS = Composite Health Care System

CLIA = Clinical Laboratory Improvement Amendments of 1998

EDC = Epi Data Center, Defense Health Agency

MHS GENESIS = Military Health System GENESIS, Health Level 7-formatted (HL-7)

NHANES = National Health and Nutrition Examination Survey



FY21 Analytical Results

Univariate Statistics for PFAS Blood Testing Among Participating DoD Personnel.

| Compound | Count | Geometric Mean ^a | 95th Percentile ^b | No. > 95th Percentile | Maximum Test Result Value |
|----------|-------|-----------------------------|------------------------------|-----------------------|---------------------------|
| PFBS | 6,785 | * | <LOD | 209 | 0.7 |
| PFHpA | 6,744 | * | 0.098 | 332 | 1.0 |
| PFHxS | 6,484 | 2.9 (2.8-2.9) | 10.0 | 254 | 340.0 |
| PFNA | 6,737 | 0.42 (0.41-0.42) | 1.0 | 281 | 8.8 |
| PFOA | 6,868 | 1.1 (1.1-1.2) | 2.9 | 331 | 24.0 |
| PFOS | 6,795 | 3.1 (3.05-3.2) | 11.0 | 296 | 150.0 |

Data from Health Level 7 (HL7) Chemistry and Military Health System (MHS) GENESIS Laboratory Results.
^a±95% Confidence Limits were calculated for the geometric mean.
^bRepresents the point at which 5% of the serum samples in the cohort exceeds that value.
 <LOD means less than the limit of detection (0.05 ng/mL).
 *Not calculated: proportion of results below limit of detection was too high to provide a valid result.
 Includes number of serum samples with a numeric test result.
 All result values are in ng/mL.
 Includes Active Duty and Non-Active Duty Personnel.
 Values are not directly comparable to National Health and Nutrition Examination Survey (NHANES) or Centers for Disease Control (CDC) Per- and Polyfluoroalkyl reporting.
 Prepared by the EpiData Center, Navy and Marine Corps Public Health Center on 06 June 2022.



FY22 Analytical Results

Univariate Statistics for PFAS Blood Testing Among Participating DoD Personnel.

| Compound | Count | Geometric Mean ^a | 95th Percentile ^b | No. of Firefighters > 95th Percentile | Maximum Value |
|----------|-------|-----------------------------|------------------------------|---------------------------------------|---------------|
| PFBS | 6,859 | * | <LOD | 171 | 0.8 |
| PFHpA | 6,816 | * | 0.1 | 332 | 1.9 |
| PFHxS | 6,687 | 2.36 (2.3-2.4) | 9.7 | 329 | 65.0 |
| PFNA | 6,787 | 0.36 (0.36-0.37) | 0.9 | 328 | 8.2 |
| PFOA | 6,925 | 1.03 (1.01-1.06) | 2.8 | 317 | 25.0 |
| PFOS | 6,859 | 2.73 (2.68-2.78) | 10.0 | 267 | 63.0 |

Data from Composite Health Care System (CHCS) Chemistry and Military Health System (MHS) GENESIS laboratory databases.

^a±95% Confidence Limits were calculated for the geometric mean.

^bRepresents the point at which 5% of the serum samples in the cohort exceeds that value.

<LOD means less than the limit of detection (0.05 ng/mL).

*Not calculated: proportion of results below limit of detection was too high to provide a valid result.

Includes number of serum samples with a numeric test result.

All result values are in ng/mL.

Includes Active Duty and Non-Active Duty Personnel.

Values are not directly comparable to National Health and Nutrition Examination Survey (NHANES) or Centers for Disease Control (CDC) Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center (EDC), Defense Centers for Public Health-Portsmouth (DCPH-P) on August 15, 2023.



Trend in FY21 and FY22 Analytical Results

Trends in Univariate Statistics for PFAS Blood Testing Among Participating DoD Personnel with Records in Both FY21 and FY22

| | FY21 | FY22 |
|------------|-----------------------------------|------------------------------------|
| Compound | Geometric Mean (n) ^a | Geometric Mean (n) ^a |
| PFBS | * (n= 3,035) | * (n= 2,981) |
| PFHpA | * (n= 3,014) | * (n = 2,964) |
| PFHxS | 2.96 (2.88-3.05); n= 2,923 | 2.61 (2.53-2.69); n= 2,933 |
| PFNA | 0.44 (0.43-0.45); n=3,015 | 0.38 (0.37-0.39); n = 2,952 |
| PFOA | 1.22 (1.18-1.25); n= 3,075 | 1.10 (1.07-1.14); n = 3,024 |
| PFOS | 3.21 (3.12-3.30); n= 3,045 | 2.93 (2.85-3.01); n=2,981 |
| Total PFAS | 8.48 (8.27-8.70); n= 2,954 | 7.60 (7.41-7.80); n= 2,954 |

Data from Composite Health Care System (CHCS) Chemistry and Military Health System (MHS) GENESIS Laboratory databases.

^a±95% Confidence Limits were calculated for the geometric mean.

*Not calculated: proportion of results below limit of detection was too high to provide a valid result.

Includes number of serum samples with a numeric test result.

All result values are in ng/mL

Includes Active Duty and Non-Active Duty Personnel.

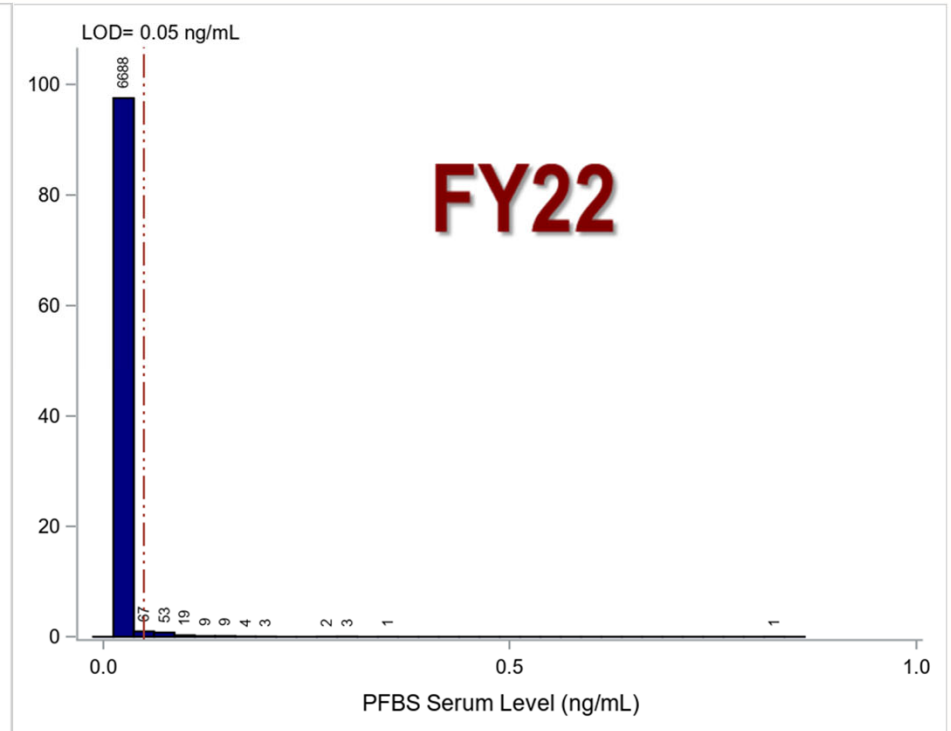
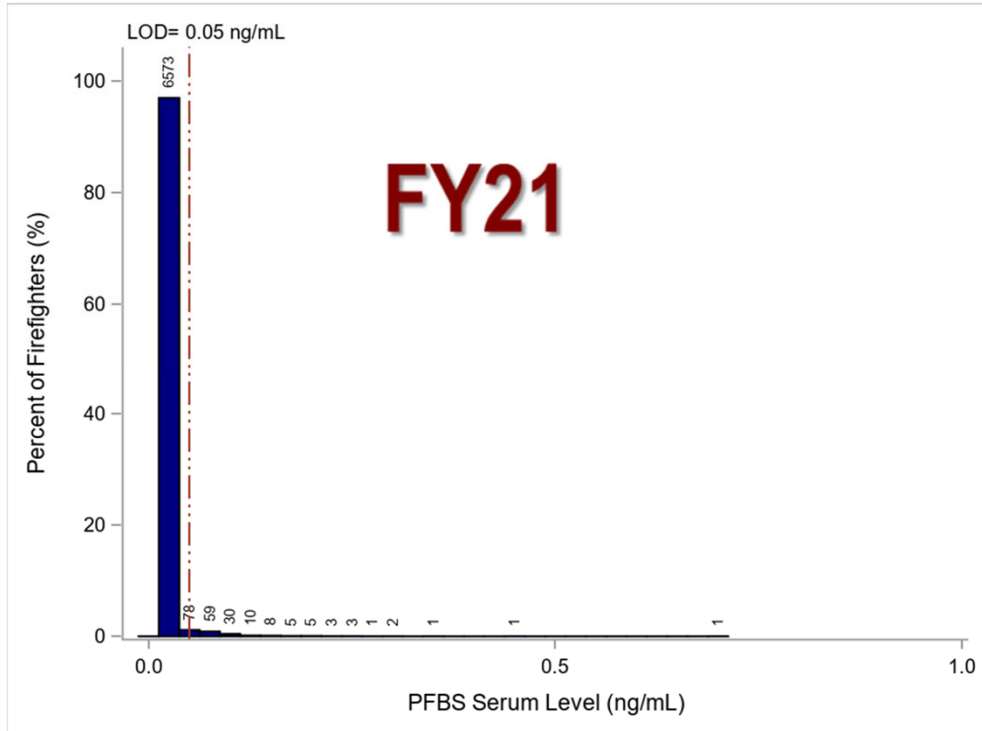
Values are not directly comparable to National Health and Nutrition Examination Survey (NHANES) or Centers for Disease Control (CDC) Per- and Polyfluoroalkyl reporting.

The limit of detection is <0.3 for total PFAS and is <0.05 for the PFAS compounds.

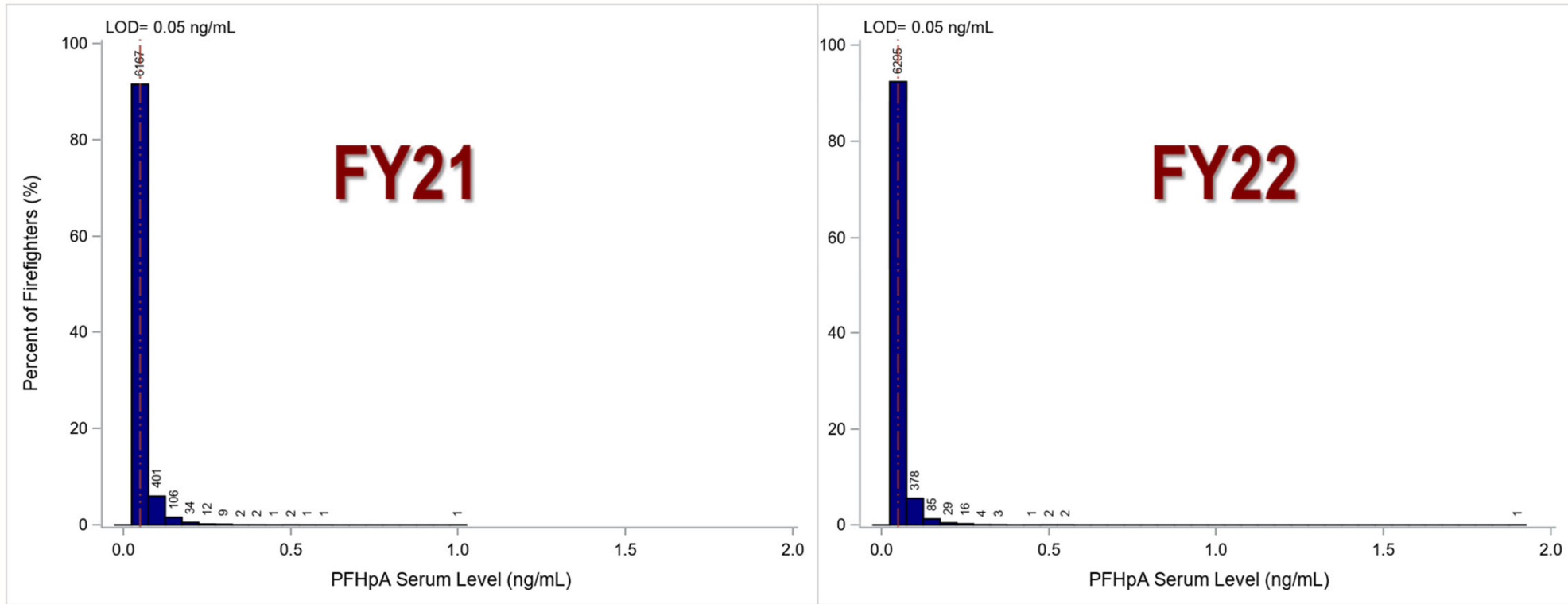
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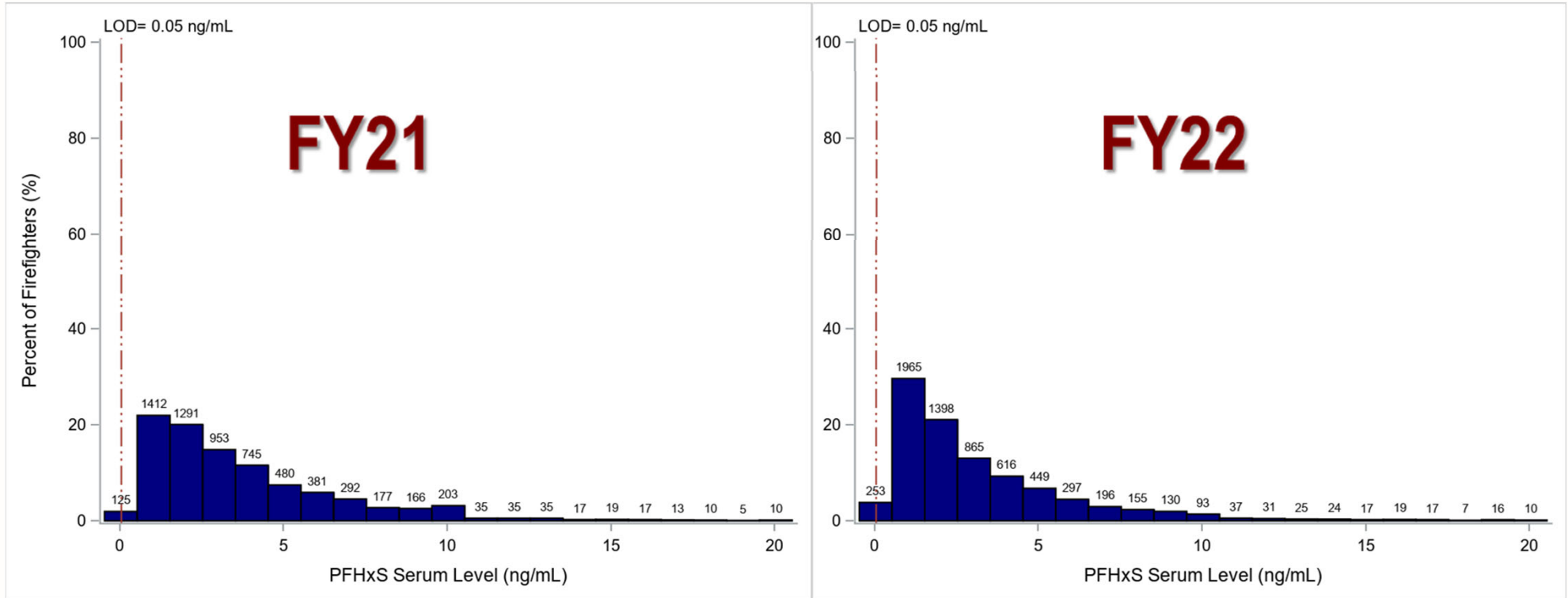
PFBS in DoD Firefighter Blood



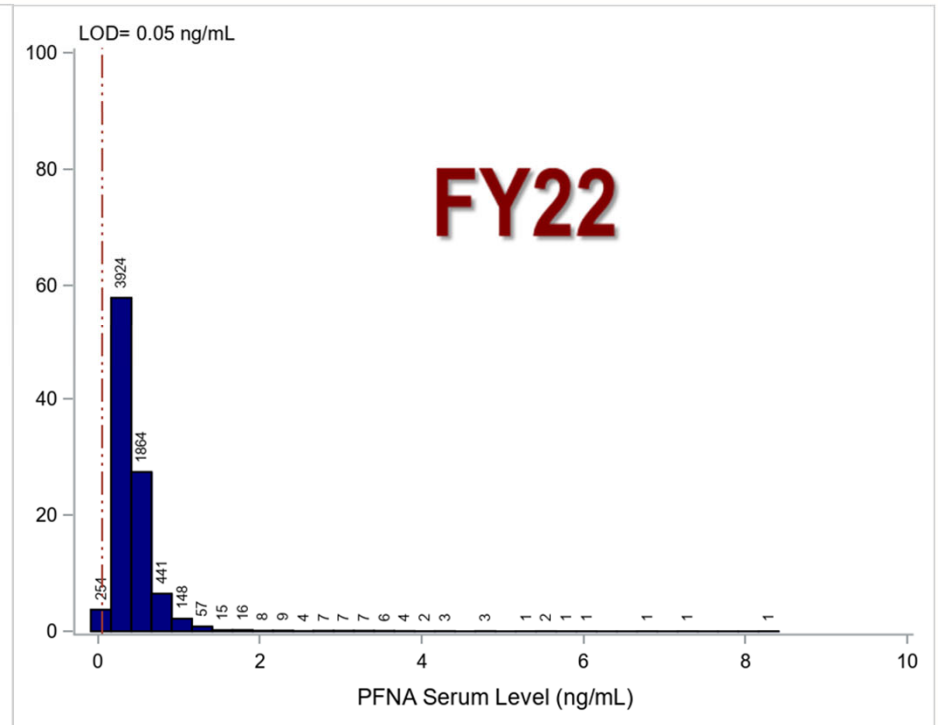
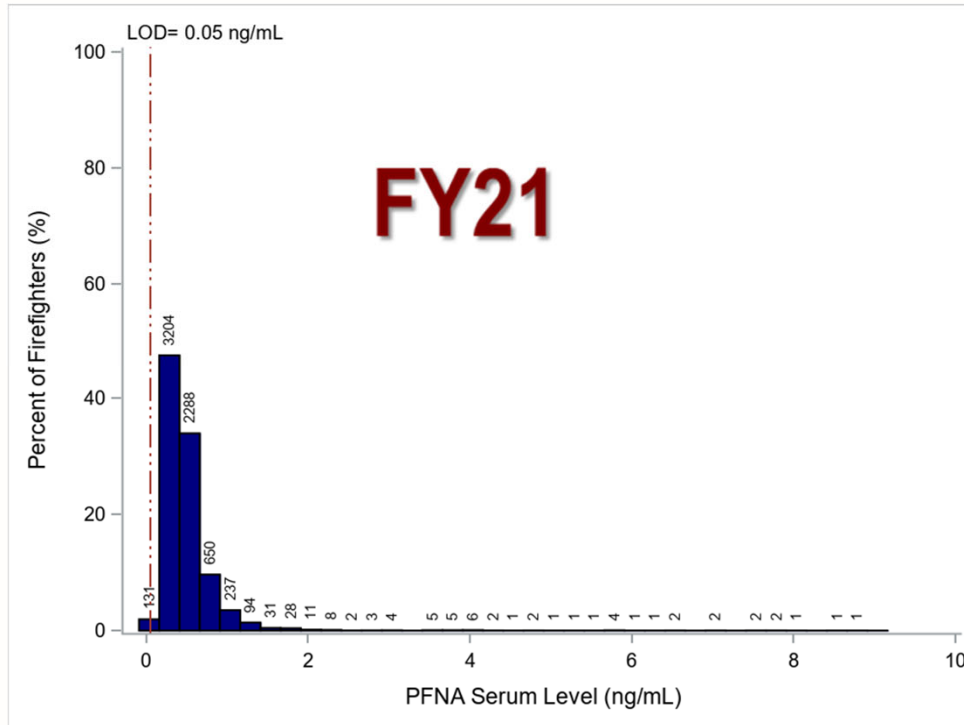
PFHpA in DoD Firefighter Blood



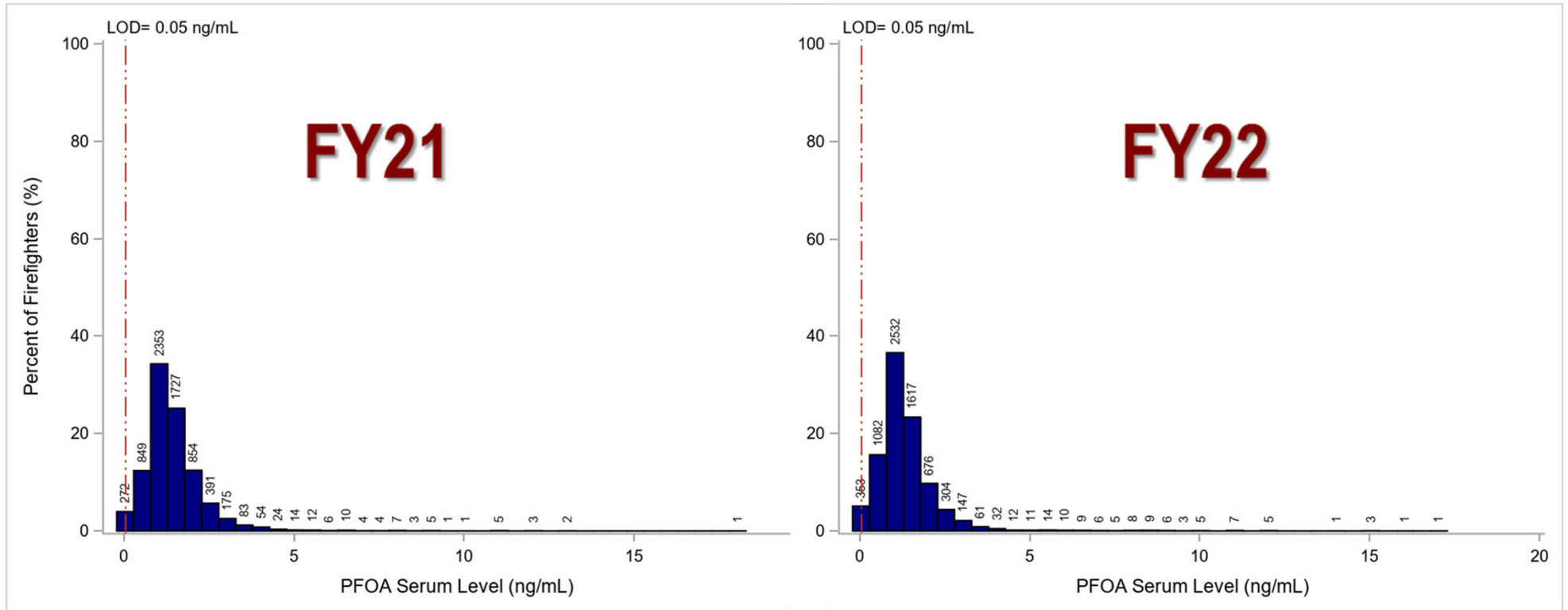
PFHxS in DoD Firefighter Blood



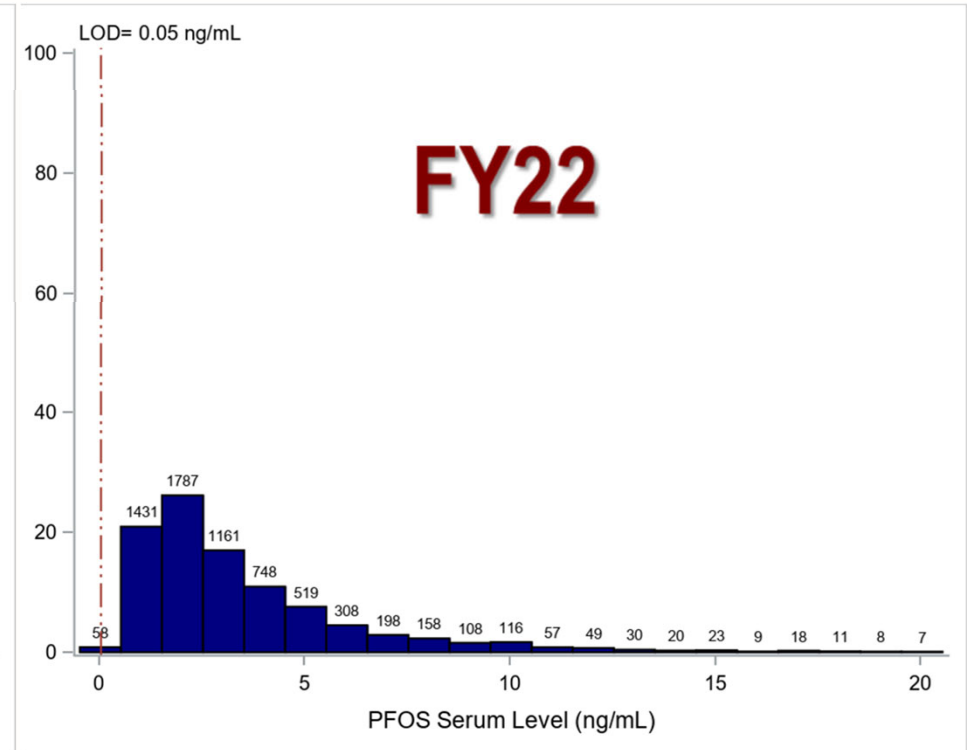
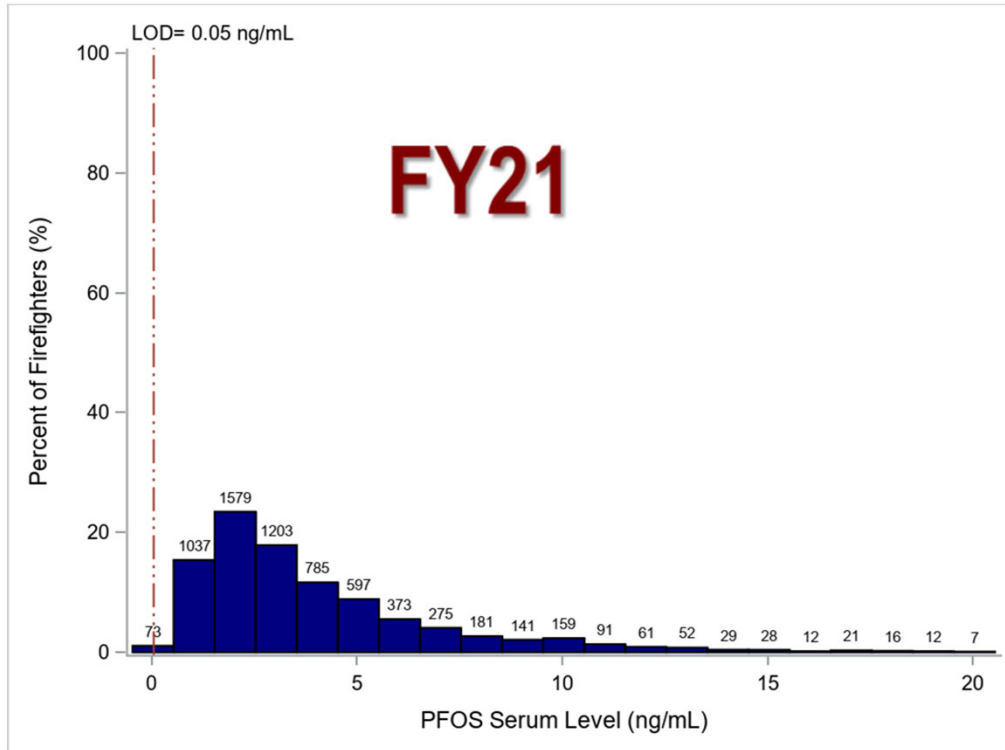
PFNA in DoD Firefighter Blood



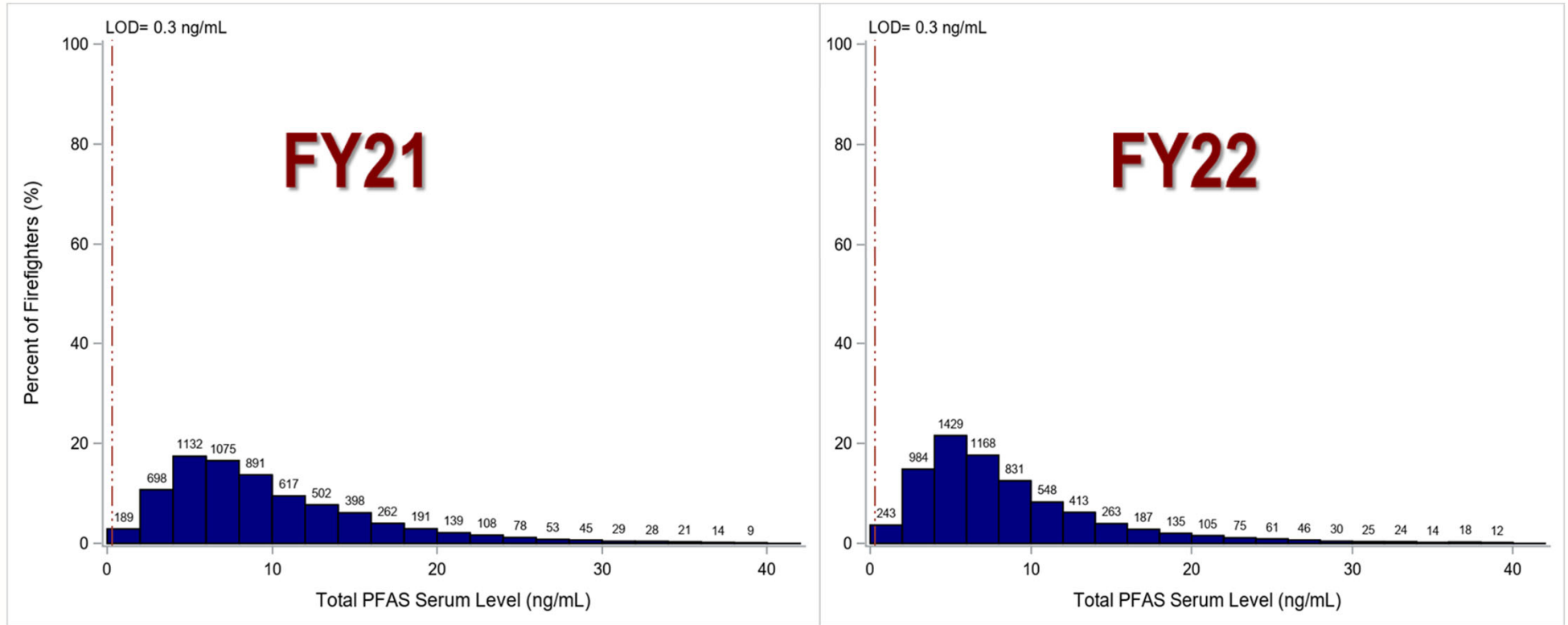
PFOA in DoD Firefighter Blood



PFOS in DoD Firefighter Blood



Total PFAS in DoD Firefighter Blood



What Can We Say About the DoD Firefighter Blood PFAS Analytical Results?

- DoD Firefighter blood PFAS levels are not comparable to those in the general population (NHANES).
- Within the DoD, use of PFAS-Containing AFFF has been limited by policy to operational emergency uses only.
- Blood PFAS levels cannot be used to determine the source, magnitude, or timing (i.e., time, frequency and duration) of PFAS exposure or whether that exposure will result in any adverse health outcome.



How Are PFAS Concentrations Expected to Change With Age and Sex?

ATSDR. 2022. PFAS Exposure Assessments. Final Report. Findings Across Ten Exposure Assessment Sites. National Center for Environmental Health, Agency for Toxic Substances and Disease

Registry. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

- Blood levels of **PFHxS**, **PFOS**, **PFOA**, and **PFNA** were statistically higher in older adult participants, and the size of the effect was stronger in females.
- Male adults had statistically higher blood levels of **PFHxS**, **PFOS**, **PFOA**, and **PFNA** than females, and the difference between males and females was larger in younger adults.

Aro et al. 2021. Organofluorine Mass Balance Analysis of Whole Blood Samples in Relation to Gender and Age. Environmental Science & Technology. 55:13142-13151.

<https://doi.org/10.1021/acs.est.1c04031>.

- Authors demonstrated statistically significant differences in the percentage of Un-identified Organofluorine (UOF) compounds between genders and with age.



Age and Sex Related Differences in PFAS Blood Levels Previously Demonstrated in Firefighters

Burgess et al. 2023. *Serum per- and polyfluoroalkyl substance concentrations in four municipal US fire departments*. Am J. Ind. Med. 66:411-423. DOI: 10.1002/ajim.23413.

- In comparison to NHANES, PFUnDA was more frequently detected in male firefighters.
- In comparison to NHANES, PFHxS and linear-PFOS concentrations were greater in female firefighters.

Graber et al. 2021. *Prevalence and Predictors of Per- and Polyfluoroalkyl Substances (PFAS) Serum Levels among Members of a Suburban US Volunteer Fire Department*. Int. J. Environ. Res. And Public Health. 18:3730. <https://doi.org/10.3390/ijerph18073730/>

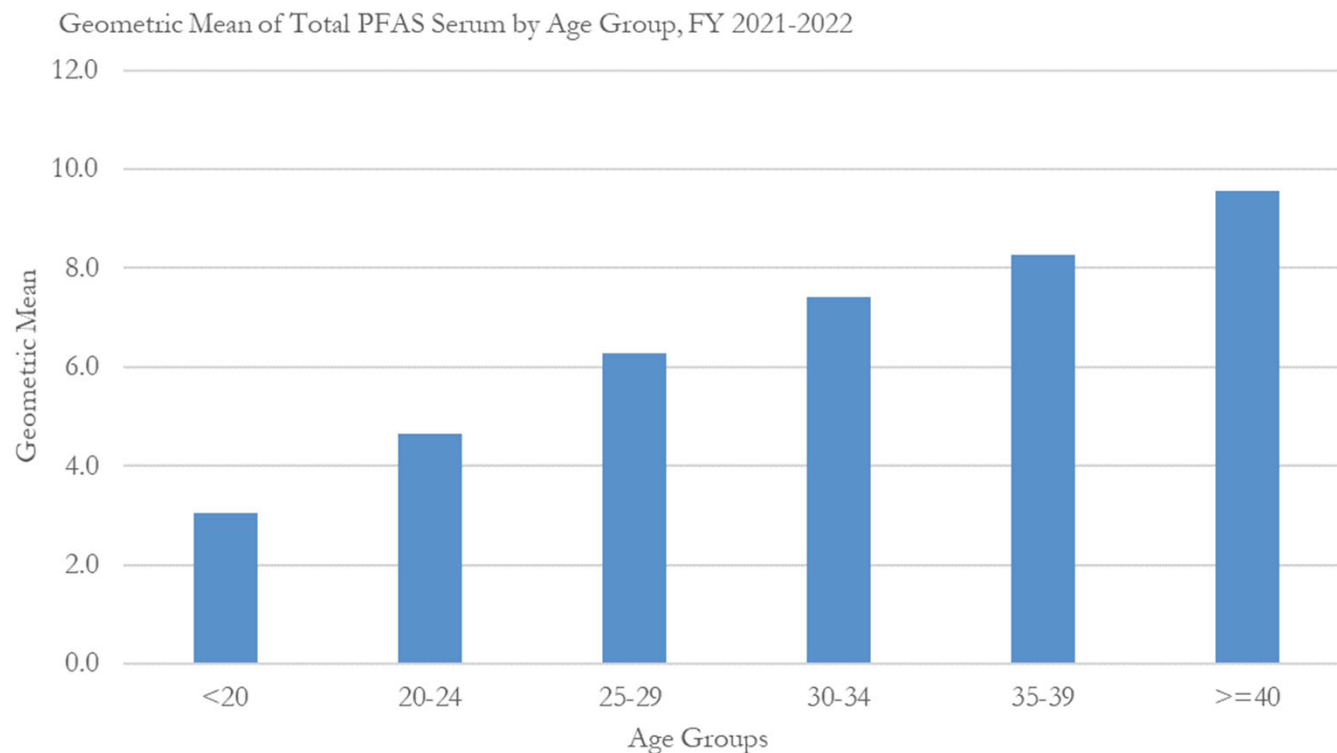
- Serum levels of both PFDA and PFDa were positively associated with years of firefighting (age).

Nair et al. 2021. *Demographic and exposure characteristics as predictors of serum per- and polyfluoroalkyl substances (PFASs) levels – A community-level biomonitoring project in Pennsylvania*. Int. J. Hygiene and Env. Health. 231:113631. <https://doi.org/10.1016/j.ijheh.2020.113631>.

- Results indicated associations between serum levels of some PFAS compounds and sex and age.



Changes in Total PFAS Concentration With Age



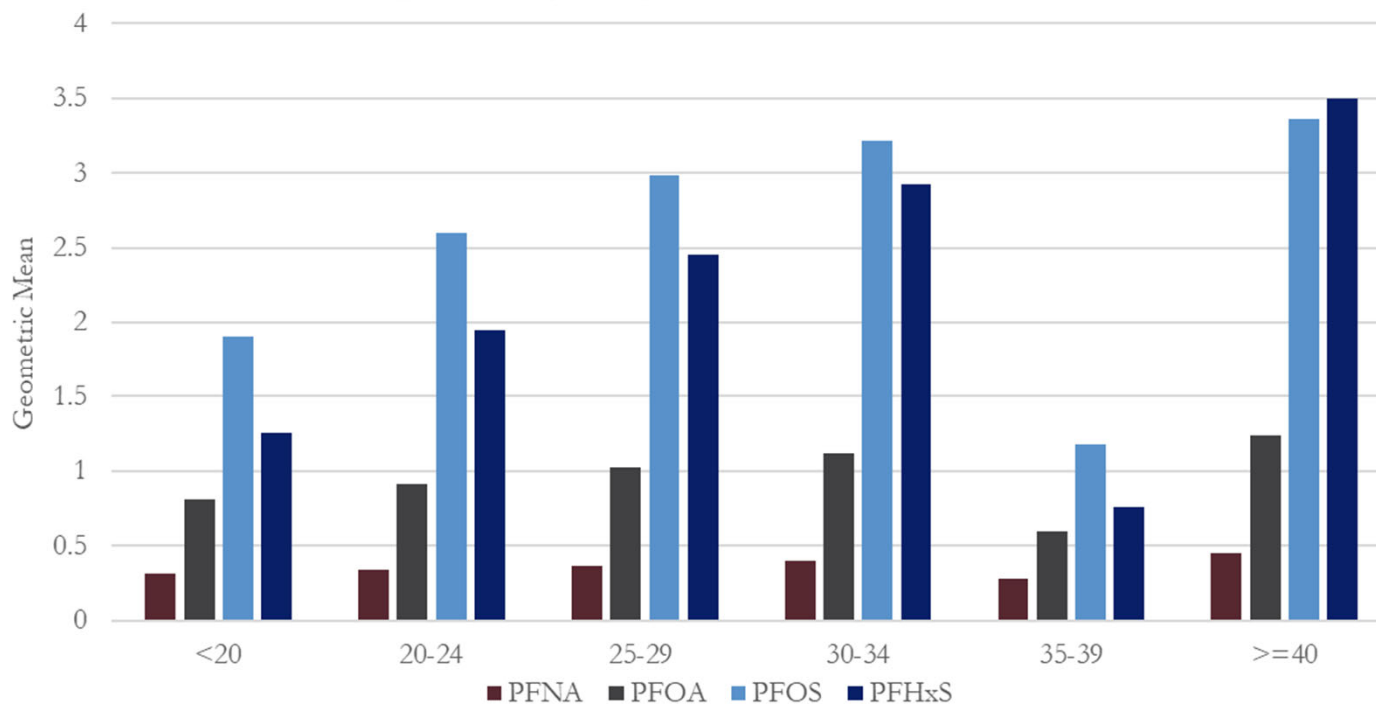
| AGE | % Sampled |
|-------------|-----------|
| <20 Years | 2.1% |
| 20-24 Years | 15.4% |
| 25-29 Years | 15.0% |
| 30-34 Years | 15.7% |
| 35-39 Years | 16.5% |
| >=40 Years | 35.2% |

Data Sources: Composite Health Care System (CHCS) and Military Health System (MHS) GENESIS Laboratory.
 Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 14, 2023.



Changes in PFAS Compound Concentration With Age

Geometric Mean of PFAS Compounds by Age Group, FY 2021-2022



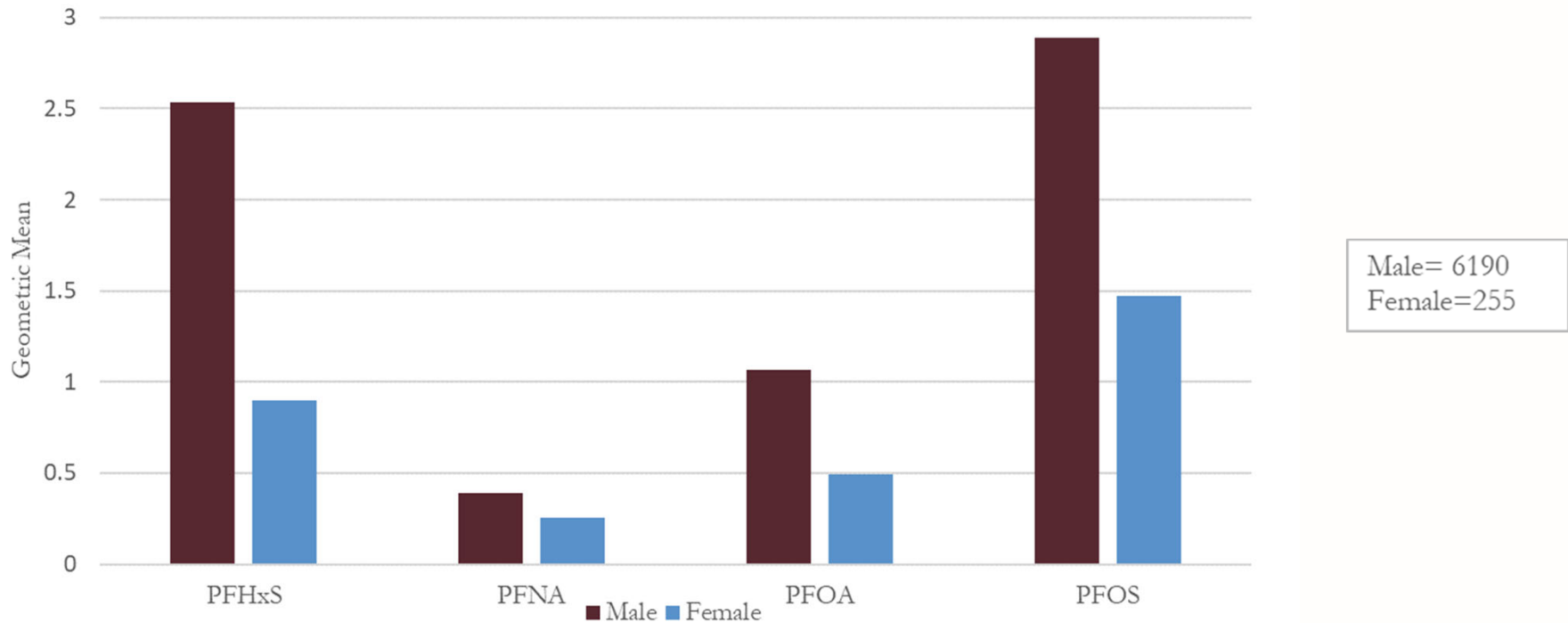
| AGE | % Sampled |
|-------------|-----------|
| <20 Years | 2.1% |
| 20-24 Years | 15.4% |
| 25-29 Years | 15.0% |
| 30-34 Years | 15.7% |
| 35-39 Years | 16.5% |
| >=40 Years | 35.2% |

Geometric means for PFBS and PFHpA was not calculated since proportion of results below limit of detection was too high to provide valid results.
 Data Sources: Composite Health Care System (CHCS) and Military Health System (MHS) GENESIS Laboratory.
 Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 14, 2023.



Changes in PFAS Compound Concentration With Sex

Geometric Means of Individual PFAS Compounds by Sex, FY 2021-2022

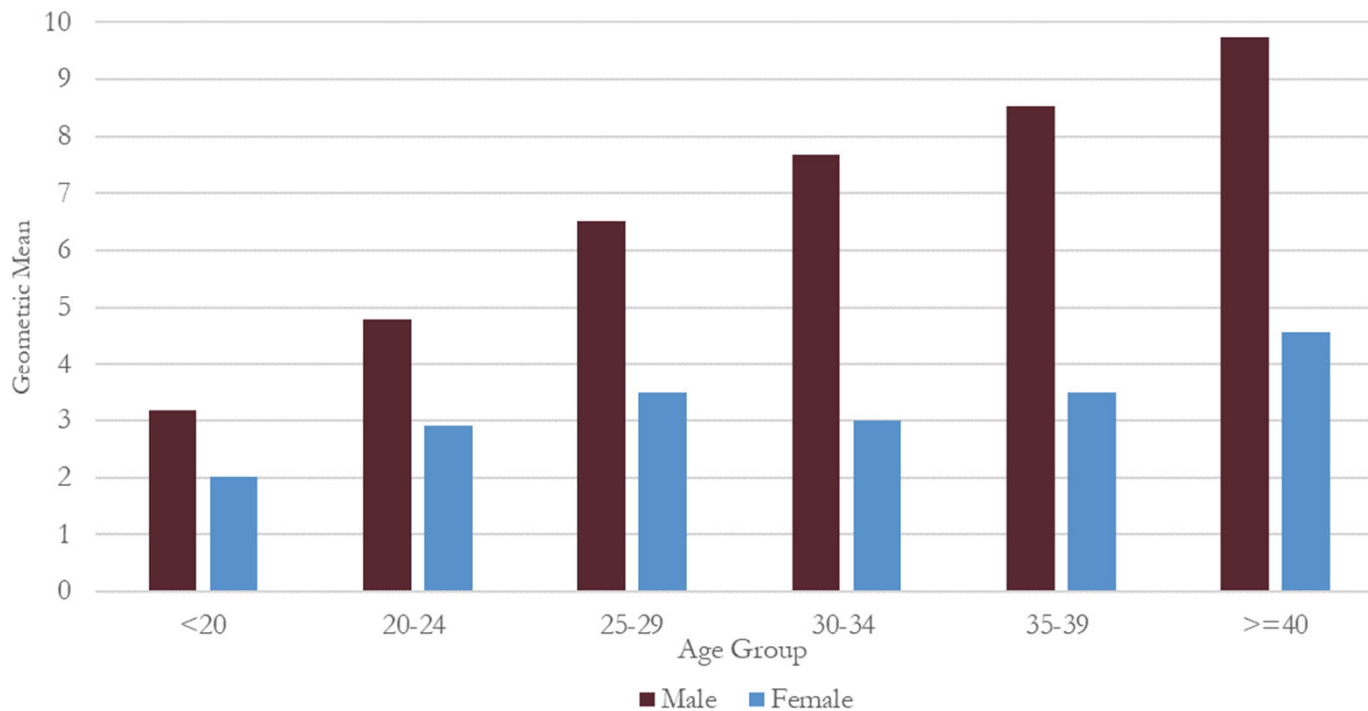


Geometric means for PFBS and PFHpA was not calculated since proportion of results below limit of detection was too high to provide valid results.
Data Sources: Composite Health Care System (CHCS) and Military Health System (MHS) GENESIS Laboratory.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 14, 2023.



Changes in Total PFAS Concentration With Age and Sex

Geometric Mean of Total PFAS Serum by Sex and Age Group, FY 2021-2022



| AGE | % MALE | % FEMALE |
|-------------|--------|----------|
| <20 YEARS | 2.1% | 5.1% |
| 20-24 YEARS | 15.3% | 21.2% |
| 25-29 YEARS | 14.9% | 22.0% |
| 30-34 YEARS | 15.7% | 14.5% |
| 35-39 YEARS | 16.7% | 14.9% |
| >=40 YEARS | 35.3% | 22.4% |

Data Sources: Composite Health Care System (CHCS) and Military Health System (MHS) GENESIS Laboratory.
 Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 14, 2023.



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CONCLUSIONS

EDC's analysis of the relationship between Firefighter Blood PFAS concentrations and firefighter age and sex confirmed the findings in the published literature.

1. PFAS tend to accumulate in firefighters with increasing age.
 - a. Age is a surrogate indicator of an individual's length of employment as a firefighter.
2. There is an apparent difference in the accumulation/excretion of PFAS by gender.
 - a. PFAS accumulation/excretion by male and female firefighters varies with age.
- **General observations:**
 1. Male firefighters tend to accumulate more PFAS than females.
 2. Female firefighters of child-bearing age (i.e., 18 to 45 years of age) accumulate less PFAS than similarly aged male peers.
 3. The accumulation of PFAS in female firefighters over the age of 45 tends to increase at a rate similar to their male peers.



QUESTIONS?

Please forward any questions you have to the
Navy and Marine Corps Force Health Protection Command
(NMCFHPC).

