Defense Health Agency – Public Health

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DoD Firefighter Per- and Polyfluoroalkyl Substances (PFAS) Blood (Serum) FY 2023 Surveillance Report and Trend Analysis

October 1, 2020–September 30, 2023

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DCPH-P-EDC-TR-277-2024

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Executive Summary

Background

Every year, the Department of Defense (DoD) offers blood testing to DoD firefighters during their annual medical exams. The primary objective of this report is to evaluate the blood per- and polyfluoroalkyl substances (PFAS) level results among DoD firefighters to determine central tendencies (geometric means) and identify trends (e.g., increasing or decreasing levels of PFAS). PFAS are man-made chemicals that were widely used in industry and consumer products since the 1940s. The components of PFAS break down very slowly over time. Due to the widespread use and persistence in the environment, many PFAS are found in the blood of most people, in a variety of industrial and consumer products, and in the environment.

This report summarizes blood PFAS analytical results obtained from LabCorp for DoD firefighters tested in fiscal years (FY) 2021–2023. By age group and sex, the report details the total number of firefighters' test results by service, geometric mean, and maximum detected value of each PFAS analyte, percent distributions of all PFAS analytes, and geometric means of Total Blood PFAS and target PFAS analytes (PFHxS, PFNA, Linear PFOS and PFOA). The Methods section of the full report lists all PFAS analytes .

Methodology

Prior to May 1, 2023, blood PFAS sample testing used a National Medical Services (NMS) Labs proprietary analytical methodology to assess six PFAS analytes (PFBS, PFHpA, PFHxS, PFNA, linear isomers of PFOA and PFOS). The Limit of Detection (LOD) for the proprietary methodology was 0.05 ng/mL. This methodology was updated to the Centers for Disease Control and Prevention (CDC) analytical methodology starting on May 1, 2023, which assesses an expanded list of 13 PFAS analytes (MeFOSAA, PFHxS, PFHpS, PFHxA, PFNA, PFDA, PFUnDA, PFDoDA, ADONA, linear and branched isomers of PFOA, and linear and branched isomers of PFOS). The LOD for CDC analytical methodology was 0.1 ng/mL. FY 2023 results were compared with the most recent CDC National Health and Nutrition Examination Survey (NHANES) report. A trend analysis was conducted to evaluate the change in blood PFAS levels among DoD firefighters who were tested in all three FYs (2021–2023).

Key Results

In FY 2023, linear PFOS and PFHxS were the two analytes with highest geometric mean blood PFAS concentrations. This was consistent across both proprietary and CDC analytical methodologies. PFOS and PFHxS are known to have long half-lives and may remain in the body longer than other PFAS analytes. Older DoD firefighters generally had higher geometric mean blood PFAS concentrations than younger firefighters, which is consistent with published literature. PFAS geometric means presented in this report are similar to the most recent CDC-NHANES report. Comparisons by sex show that male fighters generally had higher blood PFAS levels than females, also consistent with published literature. Results from the trend analysis showed a statistically significant downward trend across the three FYs.

Discussion

The Discussion section of the full report below contains detailed information on the DoD's transition from the proprietary methodology to the CDC analytical methodology, as well as more information on the expanded target PFAS analyte list.

Currently, the DoD firefighter blood analytical results for PFAS, by themselves, do not allow determination of the magnitude and timing of PFAS exposures or the likely source of the exposures.

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Background

PFAS refers to a large and complex class of man-made fluorinated chemicals.[1] Of the many chemicals categorized as PFAS, perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), were historically the most widely used throughout the U.S. and are the best studied PFAS.[2] PFAS have been used in many industrial and consumer products because their ability to repel stains, water, and grease, and increase resistance to chemicals, heat, and electricity. Commercial and consumer use of PFAS, which began in the 1940s, included non-stick cookware and certain fast-food packaging.[1-5] Additional information concerning exposure to PFAS can be found on the CDC Agency for Toxic Substances and Disease Registry (ATSDR) website.[3]

Certain PFAS analytes are known to be extremely persistent in the environment, which means they do not break down readily and therefore, accumulate over time. Because of potential health concerns, PFOS and PFOA were voluntarily removed from commercial products more than 10 years ago, and the DoD adopted policies limiting PFAS-containing aqueous film-forming foam (AFFF) to emergency uses.[5] Because of their historical use and current use in critical applications, PFAS remain present at low levels in some foods, consumer products, and in the environment (air, water, soil, etc.). CDC scientists report that four PFAS (i.e., PFHxS, PFOS, PFOA, and PFNA) are found in the serum of nearly all U.S. people tested.[4]

ATSDR is currently engaged in a large research effort to determine the potential health effects associated with areas of known or expected PFAS exposures among potentially exposed persons.[6] Currently, there are no established health-based reference levels for PFAS in blood, blood plasma, or blood serum. Although more research is needed, some observational studies have reported an association between high levels of certain PFAS in blood and the occurrence of adverse health outcomes (i.e., decreased vaccine efficacy, increased serum cholesterol levels, disrupted thyroid hormone status, certain cancers, and effects in the liver (i.e., dyslipidemia and changes in liver enzymes)).[4] While test results reporting the amount of PFAS in the blood are a useful measure of an individual's exposure to PFAS, they cannot identify the timing, magnitude, frequency, source of exposure, or determine the likelihood of developing any adverse health effects. Additional information concerning PFAS health effects are available from the ATSDR website.[4]

Section 707 of the National Defense Authorization Act (NDAA) for FY 2020 (NDAA 2020) directed the DoD to offer blood testing to DoD firefighters for the purpose of determining and documenting their potential exposure to PFAS. Beginning on October 1, 2020, DoD firefighters were offered blood testing for six target PFAS analytes (i.e., PFBS, PFHpA, PFHxS, PFNA, and linear isomers of PFOA and PFOS) during their annual physical exam. Collected blood samples were sent to a single, Clinical Laboratory Improvement Amendments (CLIA) certified laboratory for analysis. On May 1, 2023, the DoD expanded the number of target PFAS analytes to be assessed in DoD firefighter blood to include branched chain isomers of PFOA and PFOS, PFDA, PFUnDA, PFHpS, PFHxA, MeFOSAA, ADONA, and PFDoDA. These additional target analytes have been associated with historical AFFF formulations and/or identified in the blood of firefighters. Concurrently , the DoD began using the CDC analytical

methodology to allow for direct comparison of firefighter blood PFAS levels with those measured in the general U.S. population by the CDC and reported in the NHANES. The blood PFAS levels in DoD firefighters before May 1, 2023, are not comparable to those obtained by the CDC from the general population and reported in NHANES due to differences in analytical methodologies. Because of these same methodological differences and the limited target analyte list used in FYs 2021, 2022, and the first part of 2023, only linear PFOA, PFNA, and PFHxS blood serum levels are available for use in trend analysis. As a result, the analyses of the analytical results from samples collected after May 1, 2023, are presented separately from earlier sample analytical results. The EpiData Center (EDC) evaluates these later sample analyses through a comparison to reported CDC-NHANES blood PFAS levels surveyed from FYs 2017 to 2018 for individuals 20 years of age and older in the general population. The EDC also evaluated the trend in DoD firefighter blood PFAS levels between October 1, 2020, and April 30, 2023, and how PFAS levels varied with age and sex.

This report summarizes blood (serum) PFAS analytical results obtained from Laboratory Corporation of American Holdings (LabCorp) laboratory electronic testing records for DoD firefighters tested between October 1, 2022, and September 30, 2023, and evaluates trends in blood PFAS serum levels for participating DoD firefighters sampled in FYs 2021–2023.

Methods

All DoD firefighter blood PFAS sample testing was performed by the NMS Laboratory, a CLIA certified laboratory. The use of a CLIA-certified laboratory allows for the individual DoD firefighter's laboratory report to be attached to their medical record. NMS used a proprietary analytical methodology from October 1, 2020, to May 1, 2023, to assess six PFAS analytes in firefighter blood serum: PFBS, PFHpA, PFHxS, PFNA, and linear isomers of PFOS and PFOA. The LOD for this proprietary analytical methodology was 0.05 ng/mL.

The DoD adopted the CDC analytical methodology for the analysis of all DoD firefighter blood PFAS samples collected after May 1, 2023. Concurrently, the DoD adopted an expanded target PFAS analyte list to characterize DoD firefighter PFAS exposures more fully. The expanded target PFAS analyte list includes MeFOSAA, PFHxS, PFHpS, PFHxA, PFNA, PFDA, PFUnDA, PFDoDA, ADONA, and both linear and branched isomers of PFOS and PFOA. The LOD for the CDC analytical methodology is 0.1 ng/mL.

The EDC reports for FYs 2021 and 2022 obtained blood PFAS analytical data from the Military Health System (MHS) direct care laboratory records. These LabCorp-processed tests were provided back to the organization ordering the tests (e.g., DoD Military Treatment Facilities), which then had to upload the results into the MHS system. This process led to incomplete or dropped records and transcription errors. In 2023, the EDC began receiving direct electronic data feeds for all sampling results from LabCorp, including previously provided data, beginning from the initiation of testing in October 2020. This resulted in data with fewer transcription errors and higher numbers of valid results. Corrected PFAS test results from FYs 2021 and 2022 are included in the appendices of this report.

The EDC used the same statistical procedures used by the CDC in reporting blood PFAS levels. These included univariate statistics (total number of tests performed, geometric mean, and maximum concentration levels) for each of the target PFAS analytes.[11] Analytical results below the LOD (0.05 ng/mL for proprietary methodology and 0.1 ng/mL for CDC analytical methodology) or with a test result of "None Detected" were reported as "less than the Limit of Detection" or "<LOD." To compute geometric means for proprietary tests (October 1, 2020–April 30, 2023), the EDC assigned values

below the LOD as equal to the LOD (0.05 ng/mL) divided by the square root of two (0.035 ng/mL). To compute geometric means for CDC analytical methodology results, the EDC assigned values below LOD (0.1 ng/mL) divided by the square root of two (0.085 ng/mL). If more than 40% of a PFAS analyte's test results were below the LOD, a geometric mean was not calculated.

For a variety of reasons, a firefighter's blood PFAS levels may have been sampled and analyzed more than once during a reporting period. Some individuals were tested multiple times within a fiscal year or had two valid test panels from the same collection date with different PFAS analyte values (not duplicates). For these individuals, the following approach was used to determine which tests to retain for analysis:

- If 2 or more tests were conducted within 30 days from each other during the same FY (a virtual duplicate), a relative percent difference (RPD) was calculated for the 2 results:
    - If the RPD of the multiple test results was greater than 20%, it was assumed that 1 of the analytical results was in error, and the later test result was arbitrarily selected for use in all subsequent data evaluations.
    - If the RPD was less than 20%, the sample with the highest analytical result was used in all subsequent data evaluations.
- If a firefighter had multiple blood PFAS test results obtained in the same fiscal year and more than 30 days apart, all blood PFAS test results were included in the EDC's analysis. This was done to account for changes in blood PFAS levels resulting from potential exposure to and clearance/elimination of PFAS during the interval between the samples.

This report uses LabCorp electronic data as the sole source of information on DoD firefighter blood PFAS levels. FYs 2021 and 2022 blood PFAS levels were analyzed to provide a retrospective data review. Appendix A reports the revised blood PFAS serum levels for FYs 2021 and 2022.

The EDC developed the calculation of Total Blood PFAS levels in DoD firefighters (i.e., the sum of three PFAS target analytes [PFHxS, PFNA, and the linear isomer of PFOA]) to estimate a firefighter's exposure to PFAS from all sources, occupational and environmental. These analytes were selected for the calculation of Total Blood PFAS in this report because the different analytical methodologies used to measure these analytes in split samples did not yield statistically different results. In contrast, the linear isomer of PFOS was not included in the trend analysis because the proprietary and CDC analytical methods detected statistically dissimilar concentrations in split blood samples. Because of differences in individual PFAS toxicities (e.g., different dose-responses for different effects in a variety of target tissues), Total Blood PFAS levels cannot be used to determine the potential risk to human health.[6]

To evaluate how firefighter blood PFAS test results vary with age and sex, the EDC stratified test data by age group in years (<20, 20–24, 25–29, 30–34, 35–39, 40–44, and ≥45) and sex (female and male). Appendices B through D report the serum levels of individual PFAS by age group and sex.

The EDC performed a limited trend analysis of DoD firefighter blood PFAS levels over time. Blood PFAS levels were log transformed to achieve normal distributions. Trend analysis was limited to test results from firefighters who participated in proprietary blood PFAS testing during FYs 2021–2023. The EDC used repeated measures ANOVA to determine whether the differences in blood PFAS levels were statistically different in FYs 2021–2023.

Results

Tables 1 and 2 provide the blood PFAS analytical results of 7,832 firefighters who participated in blood PFAS testing in FY 2023. Table 1 displays the unique number and percentage of DoD firefighters participating in blood PFAS testing by service. Table 2 displays the number of valid PFAS laboratory serum samples tested and the univariate statistics (i.e., geometric mean, 95% confidence interval (CI) on the geometric mean, and the maximum detected level) for the PFAS analytes tested in FY 2023. Valid test results include numeric test values and results below the LOD, while invalid test results include records where the test was cancelled or not performed.

Table 2 includes the PFAS analytes in the proprietary and CDC analytical methodologies, along with the geometric means and their associated 95% CIs reported in the latest CDC-NHANES report.[11] The latest CDC-NHANES report characterizes the blood PFAS levels in less than 2,000 individuals randomly selected for blood PFAS analyses in 2017–2018. The comparison of DoD firefighter blood PFAS levels from FYs 2021 to 2023, with those reported by the CDC in NHANES, is appropriate from an analytical perspective. However, caution should be exercised, as the CDC-NHANES blood PFAS levels are 5 to 10 years older than those in this report for DoD firefighters, and the firefighter results would have to be adjusted for age and sex. Univariate statistics were not determined for 8 PFAS analytes (i.e., MeFOSAA, PFBS, PFDA, PFDoDA, PFHpA, PFHxA, PFUnDA and ADONA), as 40% of the test results were below the applicable LOD. Appendix A presents PFAS testing by service, in addition to overall PFAS analyte univariate statistics for FYs 2021 and 2022.

Figures 1 through 17 provide a graphical representation of the DoD firefighter blood analytical results for all target PFAS analytes assessed using both proprietary and CDC analytical methodologies. To visualize the distribution of individual PFAS analyte blood analytical results, the EDC arbitrarily defined histogram bar widths (concentration bins). Figure 18 displays the distribution of firefighters' Total Blood PFAS levels (the sum of PFHxS, PFNA and linear PFOA), determined by proprietary and CDC analytical methodologies, side-by-side.

Table 3 displays the number and percentage of firefighters tested during FY 2023 by age group. Age groups were categorized to reflect approximately 10% to 20% of the tested population using 5-year intervals. Figures 19a and 19b display the Total Blood PFAS levels by age group for proprietary and CDC analytical methods. Figures 20a and 20b show the geometric means of four PFAS analytes (PFHxS, PFNA, and linear isomers of PFOS and PFOA) by age group for proprietary and CDC analytical methods. Appendix B presents FYs 2021 and 2022 PFAS data by age group.

Table 4 provides the number and distribution of firefighters tested during FY 2023 by sex. Figures 21a and 21b show side-by-side comparisons of Total Blood PFAS level by sex for proprietary and CDC analytical methodologies. Figures 22a and 22b display the geometric means for PFHxS, PFNA, and linear isomers of PFOS and PFOA by sex, for proprietary and CDC analytical methods. Appendix C includes FYs 2021 and 2022 data by sex.

Figures 23a and 23b illustrate the Total Blood PFAS levels by sex and age group for FY 2023. Figures 24a–24b and 25a–25b show PFAS analyte-specific geometric means of PFHxS, PFNA, and linear isomers of PFOS and PFOA, by age group for females and males, respectively. Appendix D includes tables with the total number of valid tests, geometric means, and maximum concentration levels for PFHxS, PFNA, and linear isomers of PFOS and PFOA, by age group for females and males for FYs 2021–2023.

Table 5 displays the total number of valid tests and geometric means for six PFAS analytes (PFBS, PFHpA, PFHxS, PFNA, and linear isomers of PFOA and PFOS), and Total Blood PFAS levels in DoD

firefighters who were tested by the proprietary analytical method in FYs 2021–2023. Geometric mean levels of PFBS and PFHpA in blood serum were not calculated, since more than 40% of the total number of test results were below the applicable LOD (0.05 ng/mL).

Statistical analyses of trends for blood PFAS levels among DoD firefighters participating in all 3 years of testing revealed downward slopes. Each of the four PFAS analytes (PFHxS, PFNA, and linear PFOA and PFOS isomers) were detected by the proprietary analytical methodology. Total Blood PFAS levels significantly decreased from FY 2021 to FY 2023 ($p<0.001$). Detected blood levels of PFHxS, linear isomers of PFOA and PFOS exhibited a statistically significant decrease in FY 2023 compared to FY 2021 and FY 2022 ($p<0.001$). The decrease in firefighter blood PFNA levels was only statistically significant from FY 2021 to FY 2022 ($p<0.001$). Please note that while the decrease in PFNA was also statistically significant from FY 2021 to FY 2023, this change is complicated by its statistically significant decrease from FY 2021 to FY 2022.

FY 2023 PFAS Testing by Service Branch

Table 1. Participating DoD Firefighters Tested for PFAS by Service Branch, FY 2023 (October 1, 2022–September 30, 2023)

Service Branch	Total Participants Tested	Percent (%)
Air Force	3848	49.1
Army	1476	18.8
Marine Corps	873	11.1
Navy	1218	15.6
Unknown/Other	417	5.3
Total	7832	100.0

Data Source: LabCorp.

Includes service members (SMs) and civilian firefighters.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 11, 2024.

PFAS Univariate Statistics and Measures of Central Tendency by PFAS Analyte

Table 2. PFAS Laboratory Testing Among Participating DoD Firefighters, FY 2023 (October 1, 2022–September 30, 2023)

Analyte	Proprietary Analytical Method						CDC Analytical Method						CDC Analysis
	October 1, 2022–April 30, 2023						May 1, 2023–September 30, 2023						NHANES **
	Total Valid Tests	Below Limit of Detection (%)[a]	Geometric Mean (ng/mL)[b]	95th Percentile (ng/mL)[c]	No. of Firefighters >95th Percentile	Maximum Value (ng/mL)	Total Valid Tests	Below Limit of Detection (%)[a]	Geometric Mean (ng/mL)[b]	95th Percentile (ng/mL)[c]	No. of Firefighters >95th Percentile	Maximum Value (ng/mL)	Geometric Mean (ng/mL)[a]
MeFOSAA							3193	96.71	*	<LOD	105	1.8	0.19 (0.18-0.21)
PFBS	4655	97.49	*	<LOD	117	0.55							*
PFHxS	4642	0.41	2.02 (1.97-2.08)	9.00	357	130	3191	0.72	1.69 (1.64-1.75)	7.90	472	62	1.11 (1.03-1.21)
PFHpS							3193	30.54	0.18 (0.17-0.18)	0.73	156	4.1	0.23 (0.20-0.28)
Total PFOS							3192	1.57	4.42 (4.27-4.57)	18.90	157	71	4.50 (4.15-4.89)
Linear PFOS	4659	1.16	2.33 (2.28-2.39)	8.60	733	91	3192	1.63	3.33 (3.23-3.44)	14.00	203	54	3.11 (2.86-3.38)
Branched PFOS							3193	2.76	1.12 (1.09-1.16)	4.40	154	17	1.39 (1.29-1.51)
PFHxA							3193	99.75	*	<LOD	8	0.55	*
PFHpA	4646	82.05	*	0.09	231	0.53							*
Total PFOA							3191	0.72	0.94 (0.92-0.96)	2.30	158	17	1.45 (1.35-1.56)
Linear PFOA	4661	6.52	0.92 (0.89-0.95)	2.50	354	24	3191	0.72	0.94 (0.92-0.96)	2.30	453	17	1.36 (1.26-1.46)
Branched PFOA							3191	99.94	*	<LOD	2	0.19	0.09 (0.09-0.10)
PFNA	4658	0.62	0.33 (0.32-0.33)	0.79	367	8.1	3193	2.29	0.30 (0.30-0.31)	0.74	422	5.8	0.42 (0.37-0.47)
PFDA							3193	55.75	*	0.33	154	3.1	0.20 (0.18-0.22)
PFUnDA							3193	75.76	*	0.27	157	2.2	0.13 (0.12-0.14)
PFDoDA							3193	99.15	*	<LOD	27	0.25	*
ADONA							3192	100.00	*	<LOD	0	<LOD	*

Data Source: LabCorp, CDC NHANES.

[a] Percent of samples with a value below the limit of detection (LOD). LOD is 0.05 ng/mL for proprietary analytical method and 0.1 ng/mL for CDC analytical method.

[b] 95% Confidence Limits were calculated for the geometric mean.

[c] Represents the point at which 5% of the serum samples in the cohort exceeds that value.

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

**Data includes individuals aged 20 and over for most recent survey years.

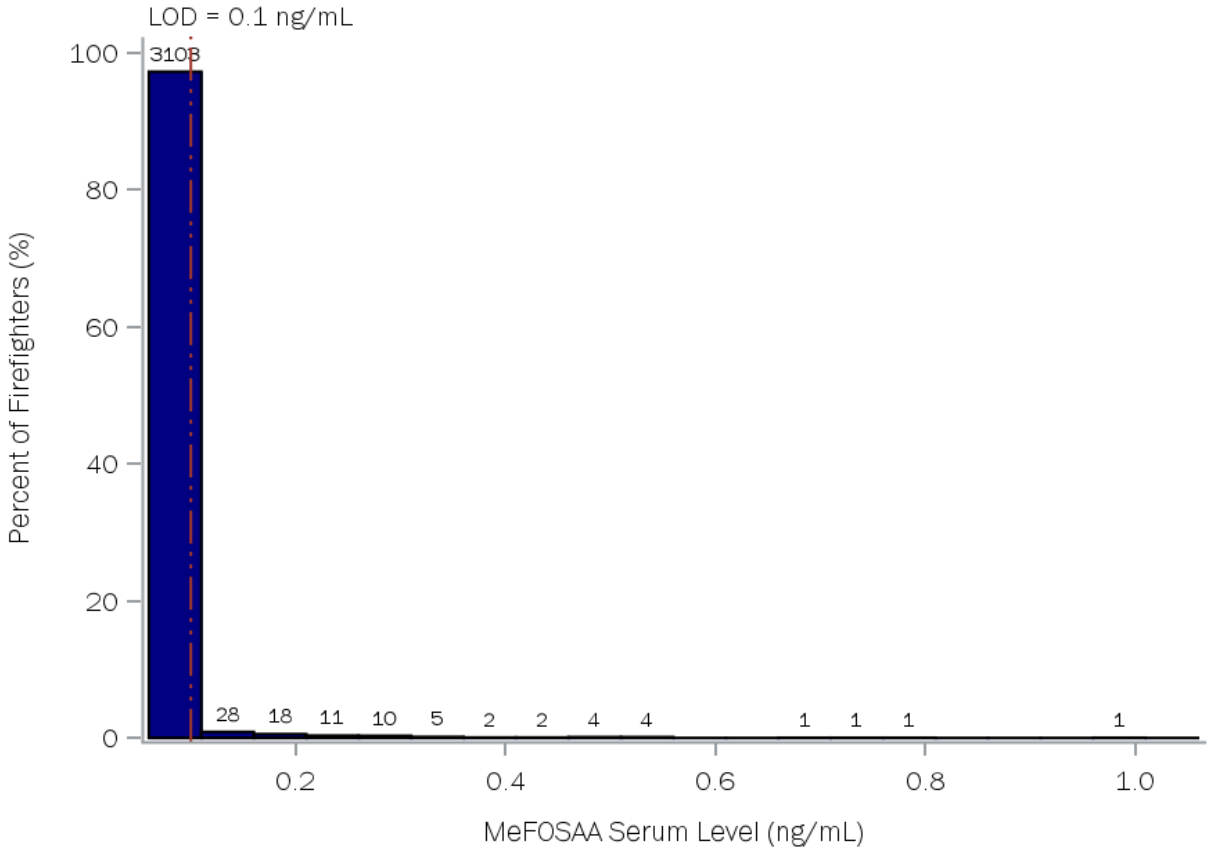
PFAS values in proprietary analytical methodology are not comparable to those obtained by the CDC from the general population and reported in NHANES, whereas, values in CDC analytical methodology are directly comparable to values reported in NHANES.

Includes service members (SMs) and civilian firefighters.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Percent Distribution of Analytical Results by PFAS Analyte

Figure 1. Percent Distribution of MeFOSAA Analytial Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

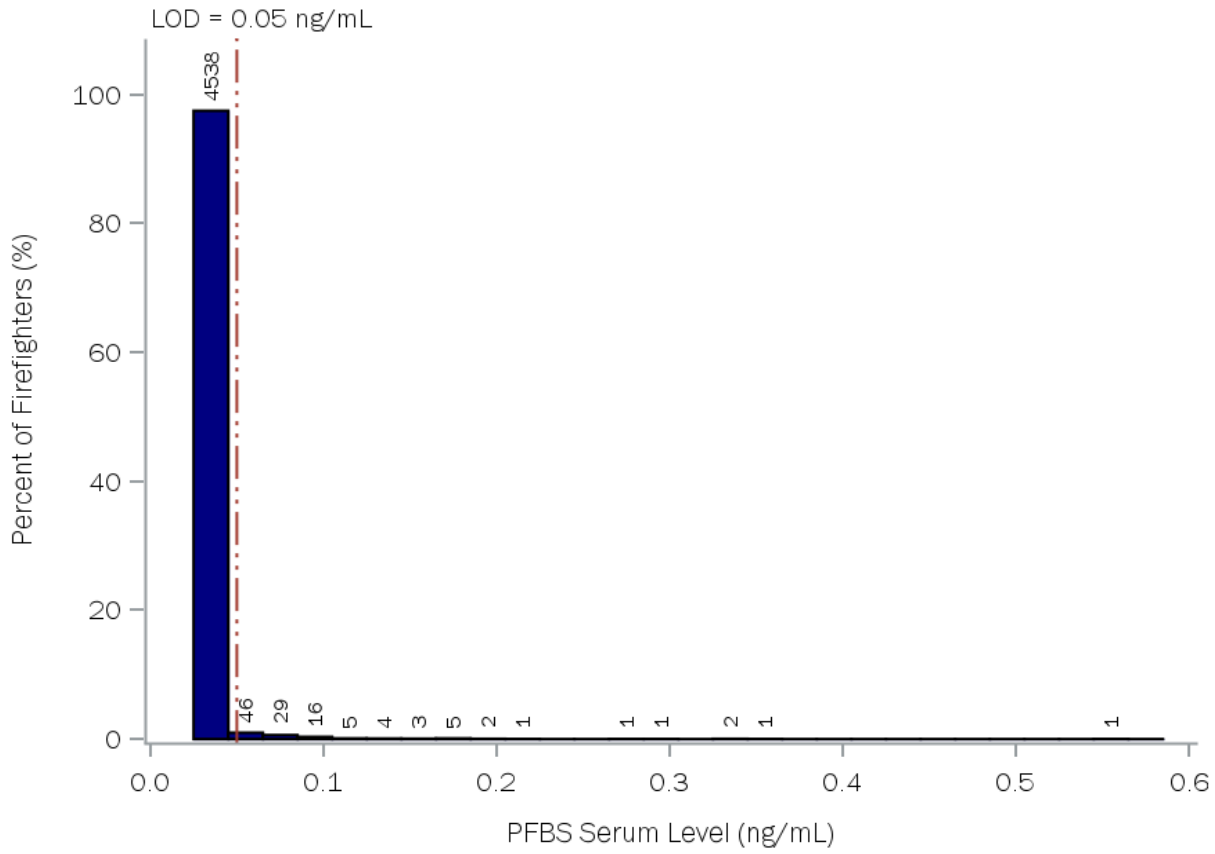
The distribution of values equal to 1 ng/mL or less is displayed in the histogram. There were two values above 1 ng/mL.

The number of records below the limit of detection (LOD)=3088. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 2. Percent Distribution of PFBS Analytical Results Among Participating DoD Firefighters Using Proprietary Analytical Methodology, October 1, 2022–April 30, 2023 (n=4655)



Data Source: LabCorp.

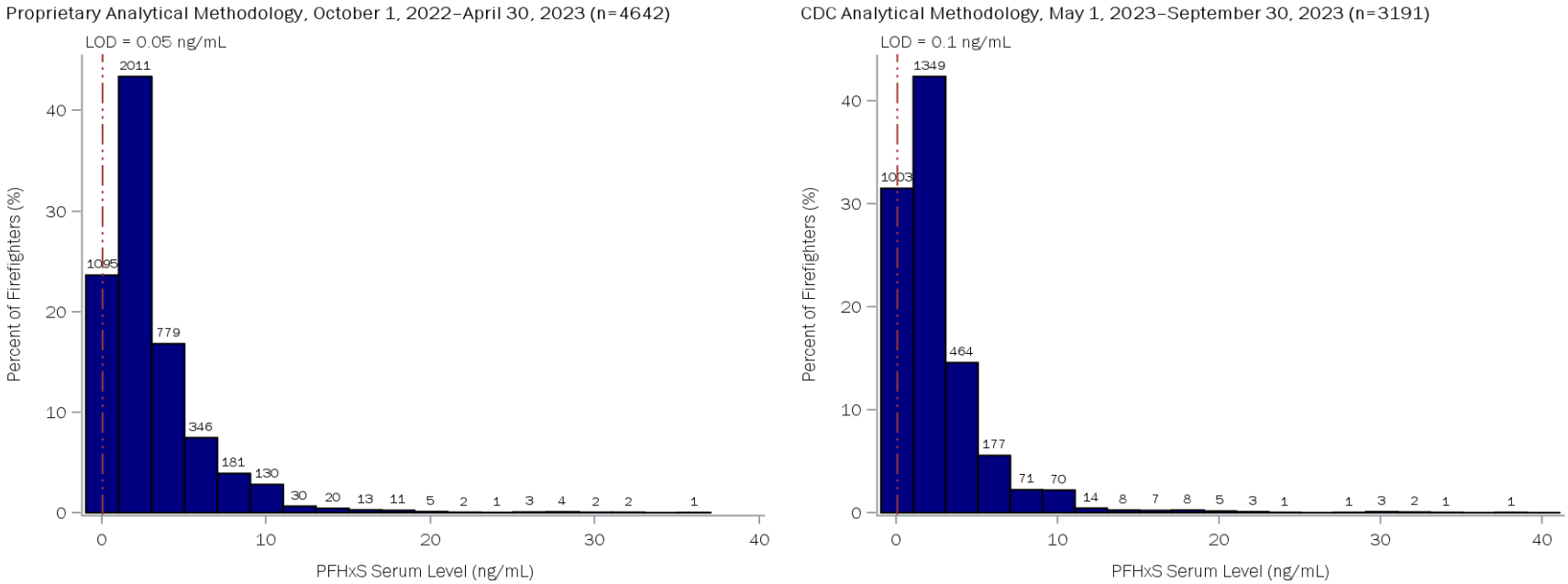
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=4538. The LOD is 0.05 ng/mL.

The CDC no longer assesses PFBS in the general population due to a lack of detections greater than the applicable LOD in prior years analyses.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Figure 3. Percent Distribution of PFHxS Analytical Results Among Participating DoD Firefighters, October 1, 2022–September 30, 2023



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

The distribution of values equal to 40 ng/mL or less is displayed in the histograms. There were six values in proprietary and three values in CDC analytical methodology above 40 ng/mL.

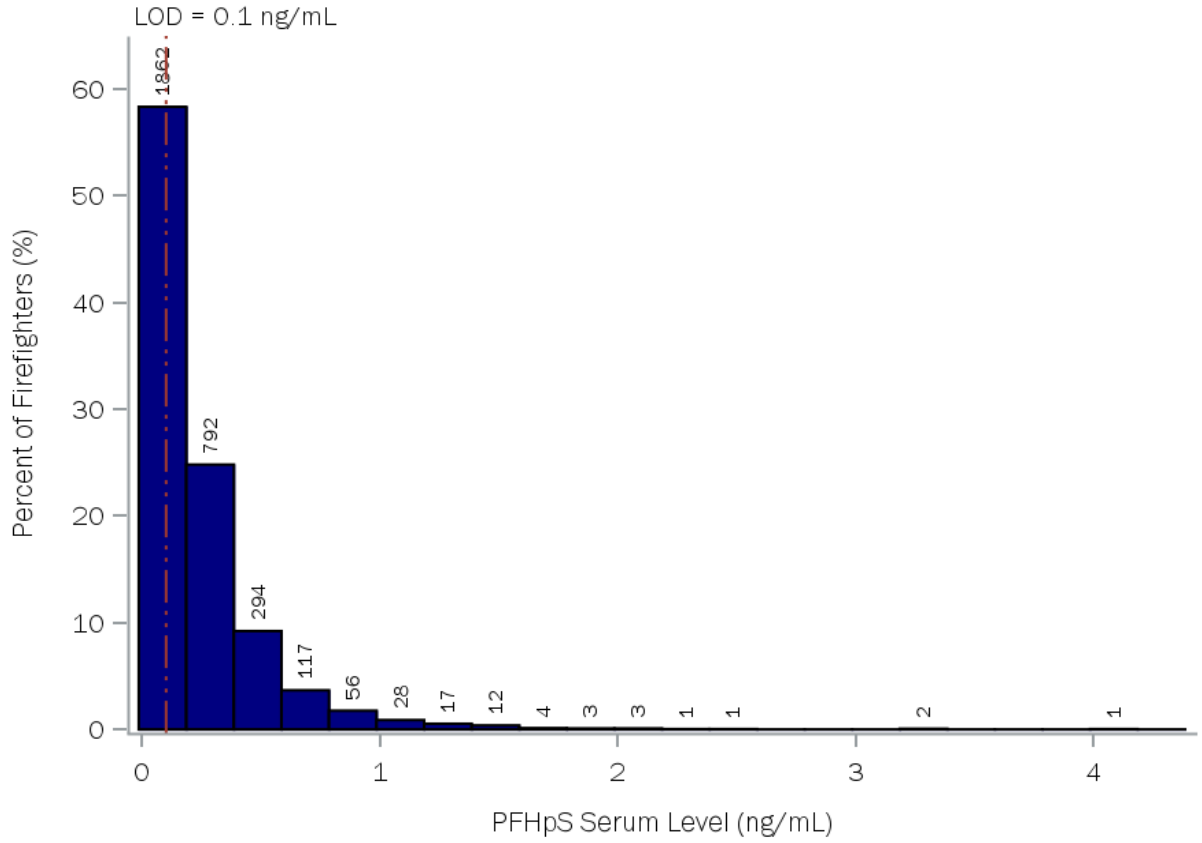
Proprietary methodology had 19 test values below limit of detection (LOD). The LOD is 0.05 ng/mL for proprietary methodology.

CDC analytical methodology had 23 test values below limit of detection (LOD). The LOD is 0.1 ng/mL for CDC analytical methodology.

PFAS values in proprietary analytical methodology are not comparable to those obtained by the CDC from the general population and reported in NHANES, whereas, values in CDC analytical methodology are directly comparable to values reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 4. Percent Distribution of PFHpS Testing Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

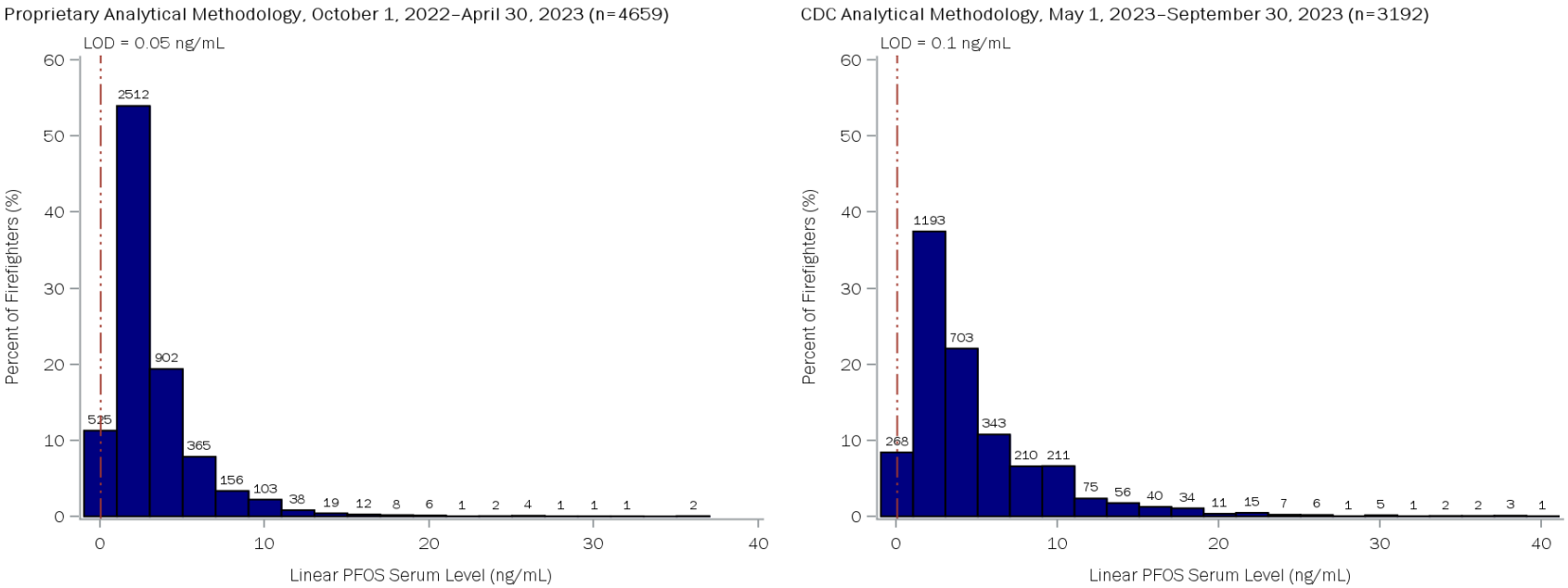
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=975. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 5. Percent Distribution of Linear PFOS Isomer Analytical Results Among Participating DoD Firefighters, October 1, 2022–September 30, 2023



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

The distribution of values equal to 40 ng/mL or less is displayed in the histograms. There were six values in propreitary and three values in CDC analytical methodology above 40 ng/mL.

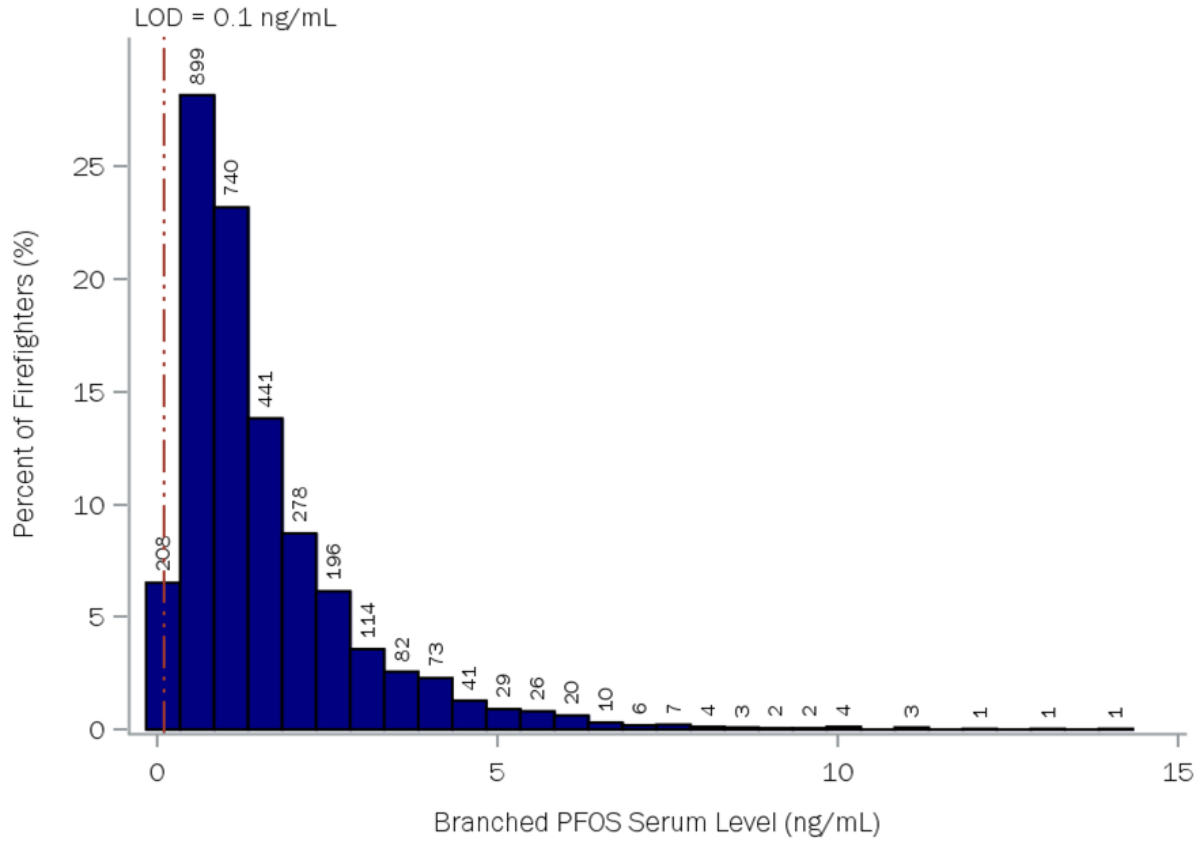
Proprietary methodology had 54 test values below limit of detection (LOD). The LOD is 0.05 ng/mL for proprietary methodology.

CDC analytical methodology 52 had test values below limit of detection (LOD). The LOD is 0.1 ng/mL for CDC analytical methodology.

PFAS values in proprietary analytical methodology are not comparable to those obtained by the CDC from the general population and reported in NHANES, whereas, values in CDC analytical methodology are directly comparable to values reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 6. Percent Distribution of Branched PFOS Isomers Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

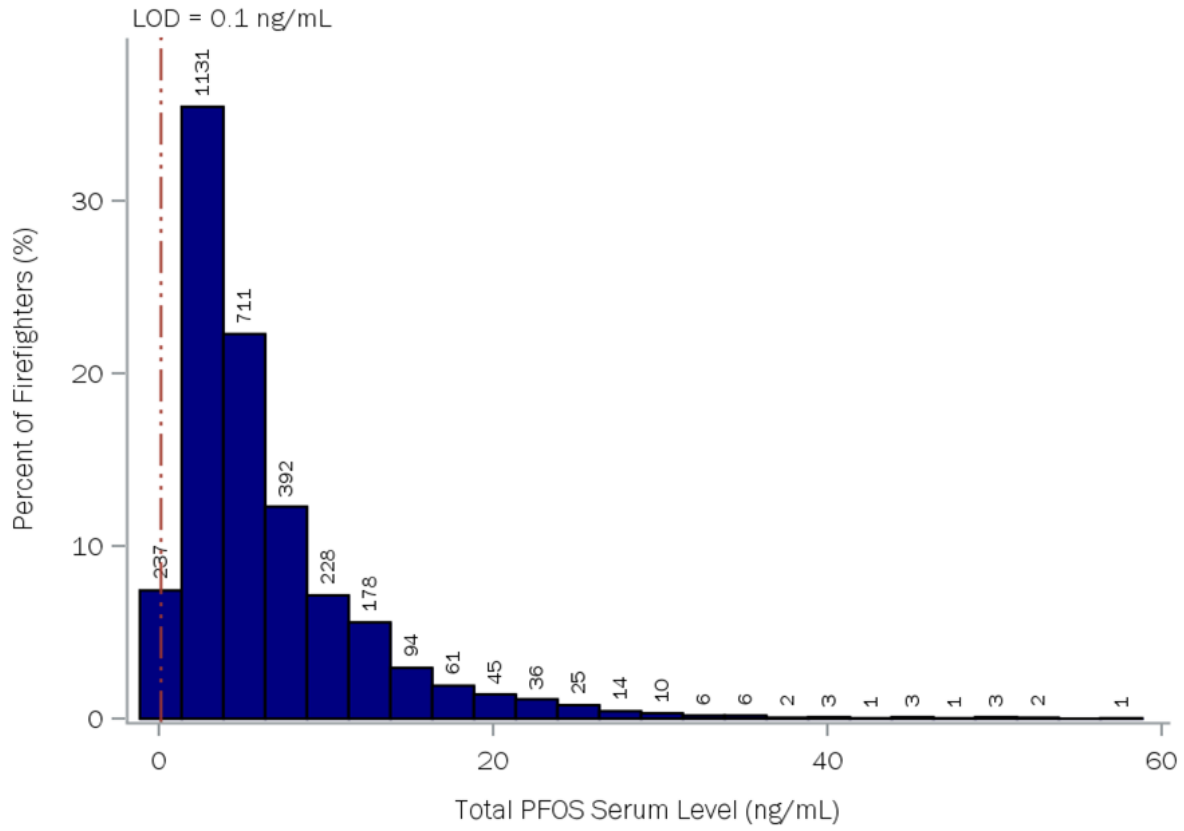
The distribution of values equal to 15 ng/mL or less is provided in the histogram. There were two datapoints above 15 ng/mL.

The number of records below the limit of detection (LOD)=88. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 7. Percent Distribution of Total PFOS Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3192)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

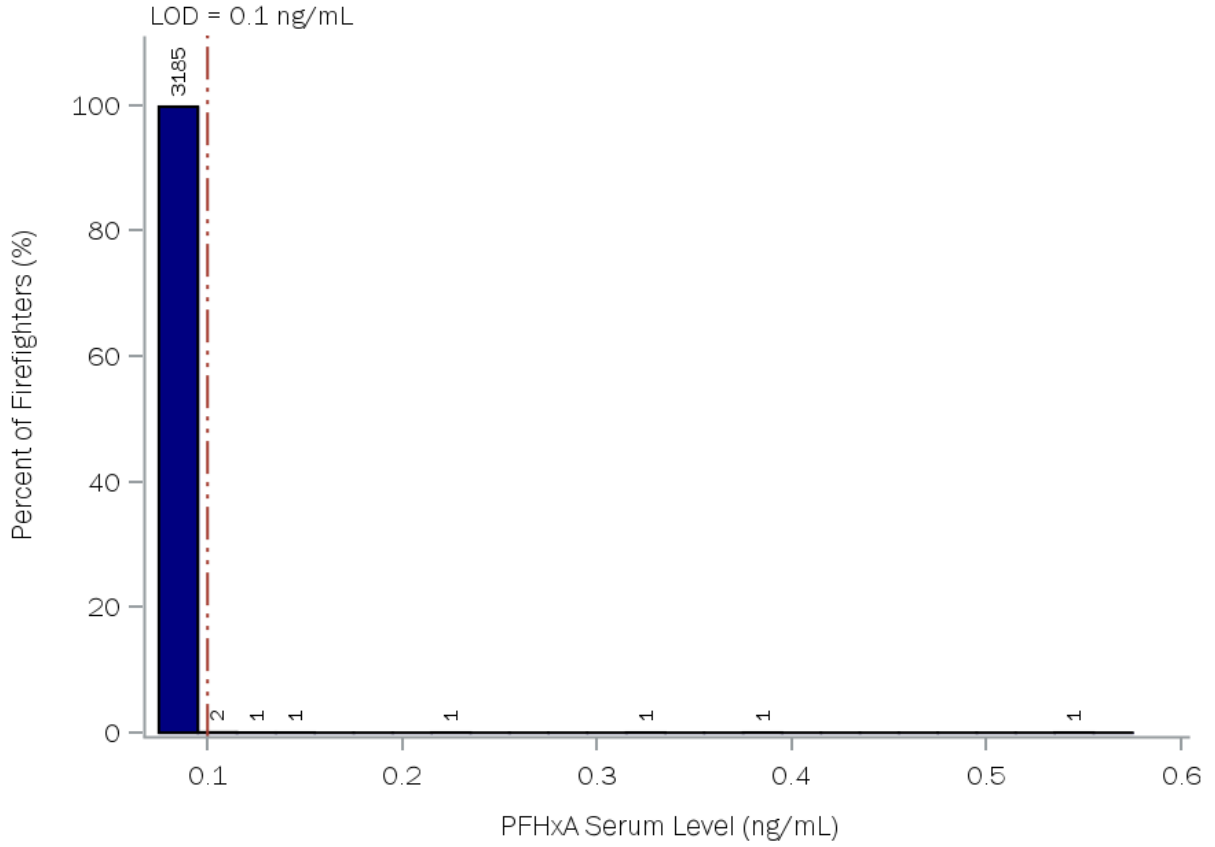
The distribution of values equal to 60 ng/mL or less is displayed in the histogram. There were two values above 60 ng/mL.

The number of records below the limit of detection (LOD)=50. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 8. Percent Distribution of PFHxA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

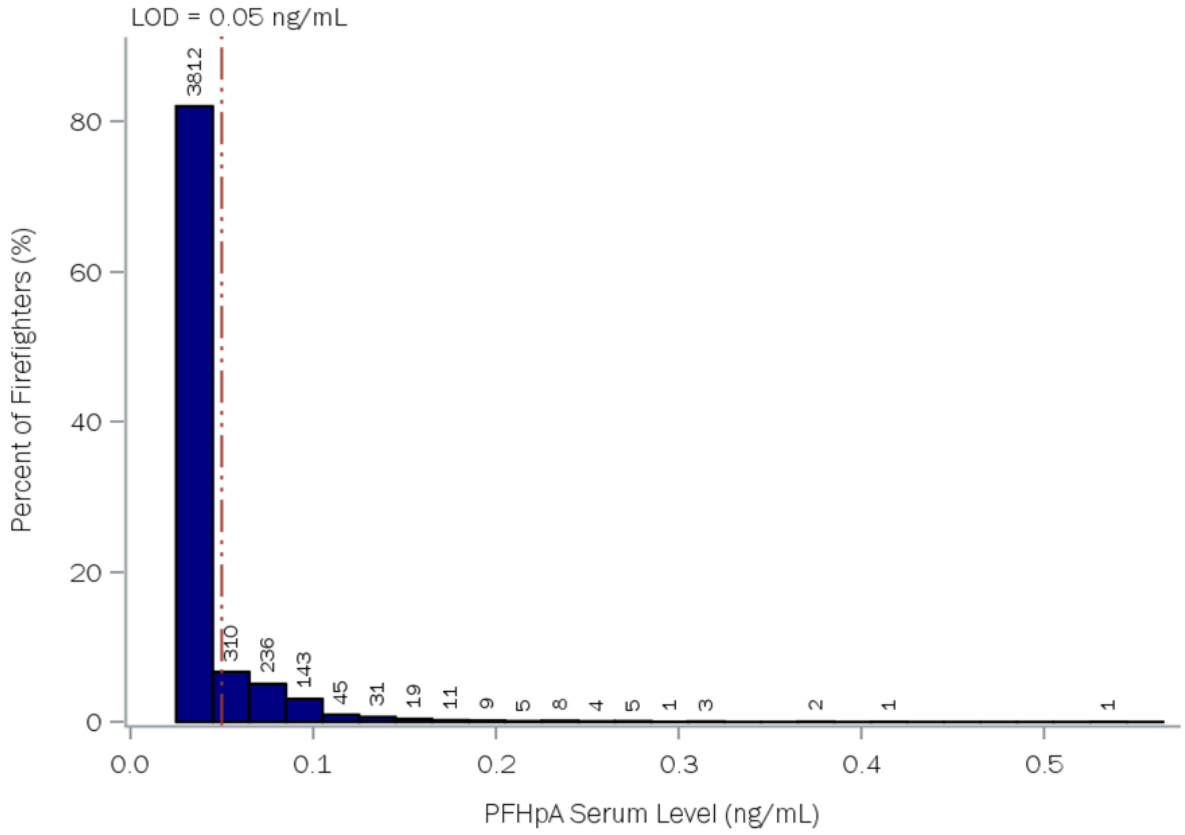
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=3185. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 9. Percent Distribution of PFHpA Analytical Results Among Participating DoD Firefighters Using Proprietary Analytical Methodology, October 1, 2022–April 30, 2023 (n=4646)



Data Source: LabCorp.

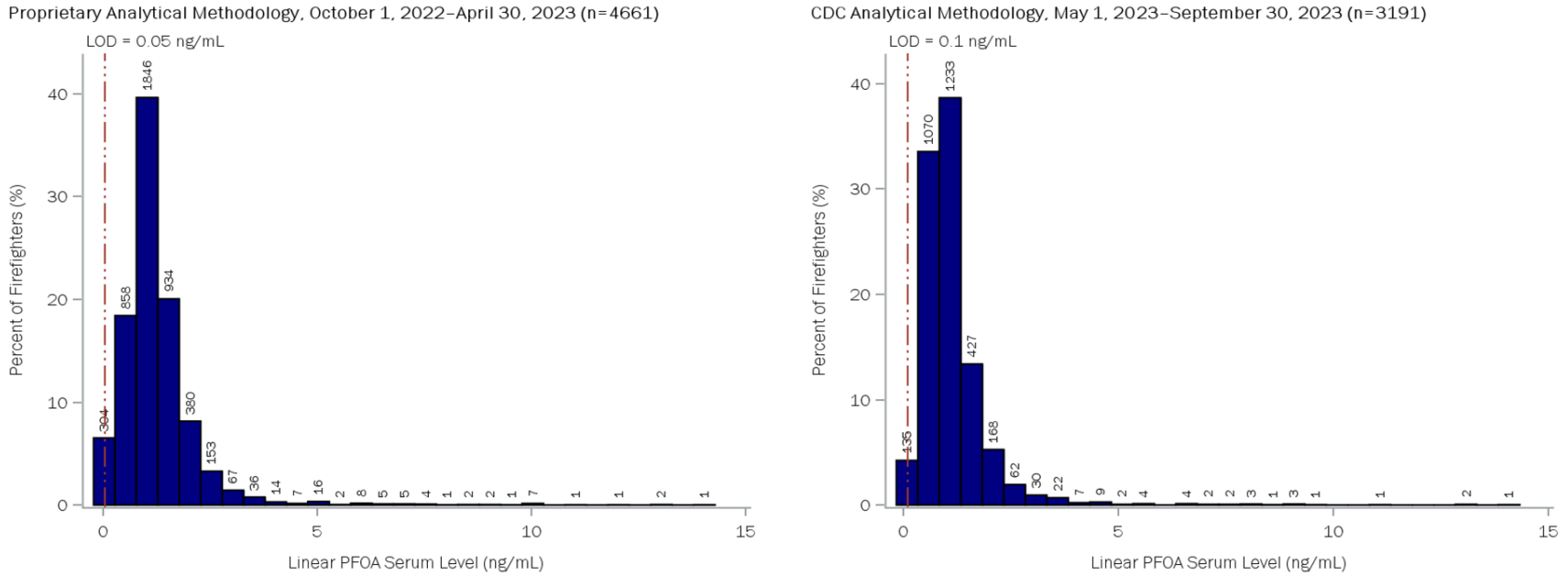
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=3812. The LOD is 0.05 ng/mL.

The CDC no longer assesses PFBS in the general population due to a lack of detections greater than the applicable LOD in prior years analyses.

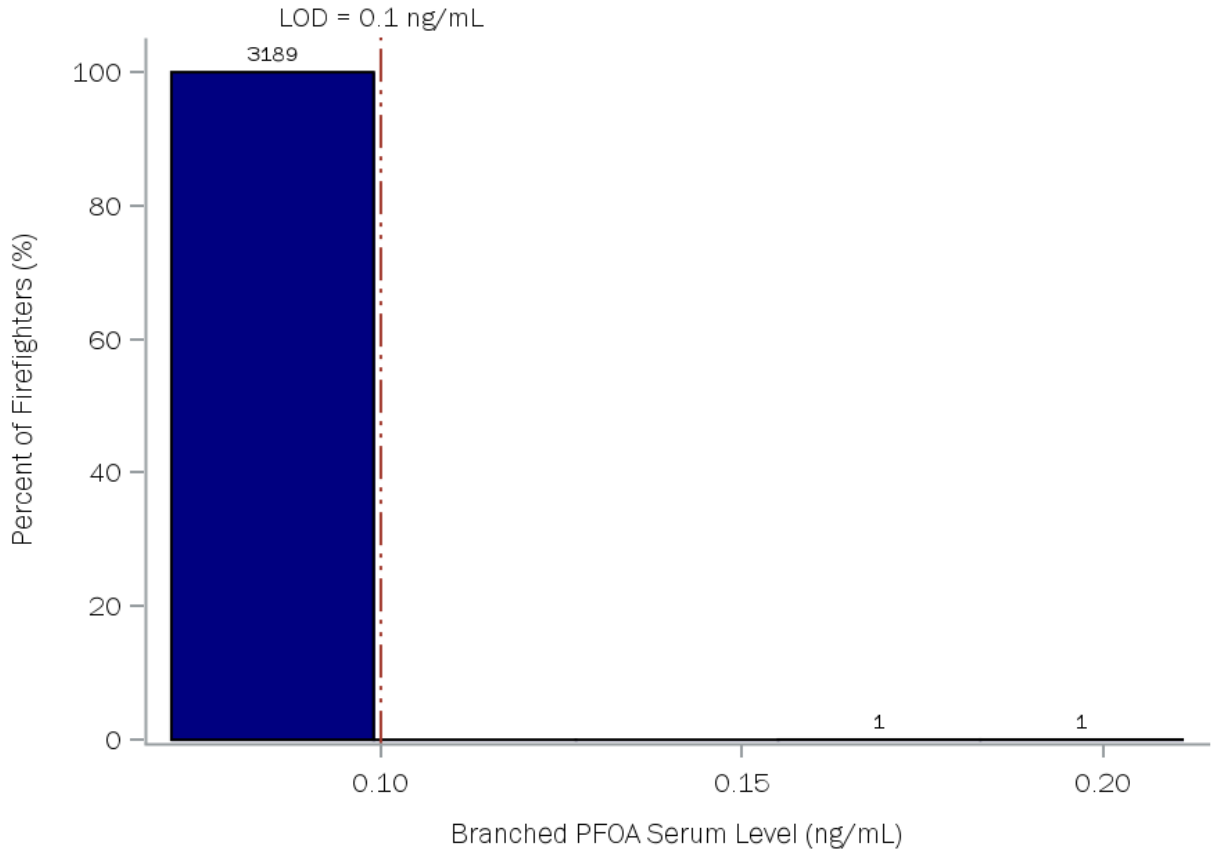
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 24, 2024.

Figure 10. Percent Distribution of Linear PFOA Isomer Analytical Results Among Participating DoD Firefighters, October 1, 2022–September 30, 2023



Data Source: LabCorp.
Figure includes service members (SMs) and civilian firefighters.
The distribution of values equal to 15 ng/mL or less is displayed in the histograms. There were four values in proprietary and two values in CDC analytical methodology above 15 ng/mL.
Proprietary methodology had 304 test values below limit of detection (LOD). The LOD is 0.05 ng/mL for proprietary methodology.
CDC analytical methodology had 23 test values below limit of detection (LOD). The LOD is 0.1 ng/mL for CDC analytical methodology.
PFAS values in proprietary analytical methodology are not comparable to those obtained by the CDC from the general population and reported in NHANES, whereas, values in CDC analytical methodology are directly comparable to values reported in NHANES.
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 11. Percent Distribution of Branched PFOA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3191)



Data Source: LabCorp.

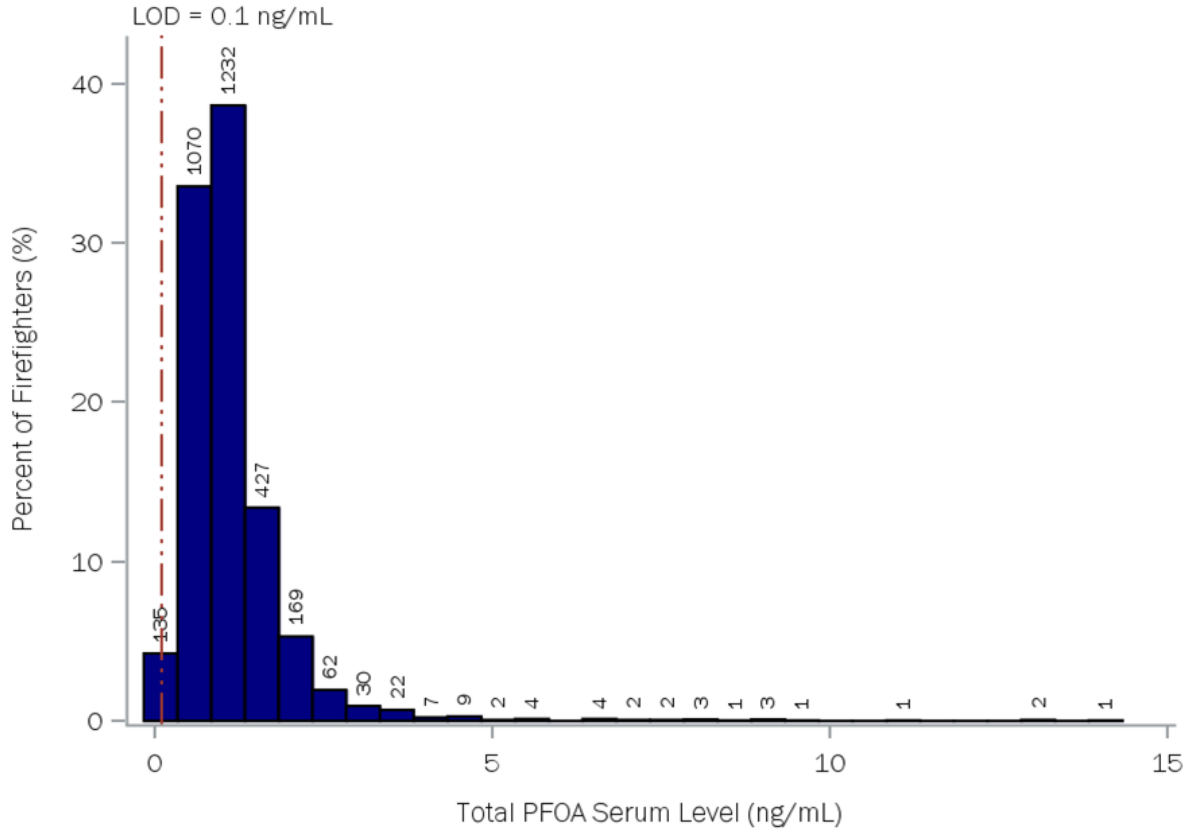
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=3189. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 12. Percent Distribution of Total PFOA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3191)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

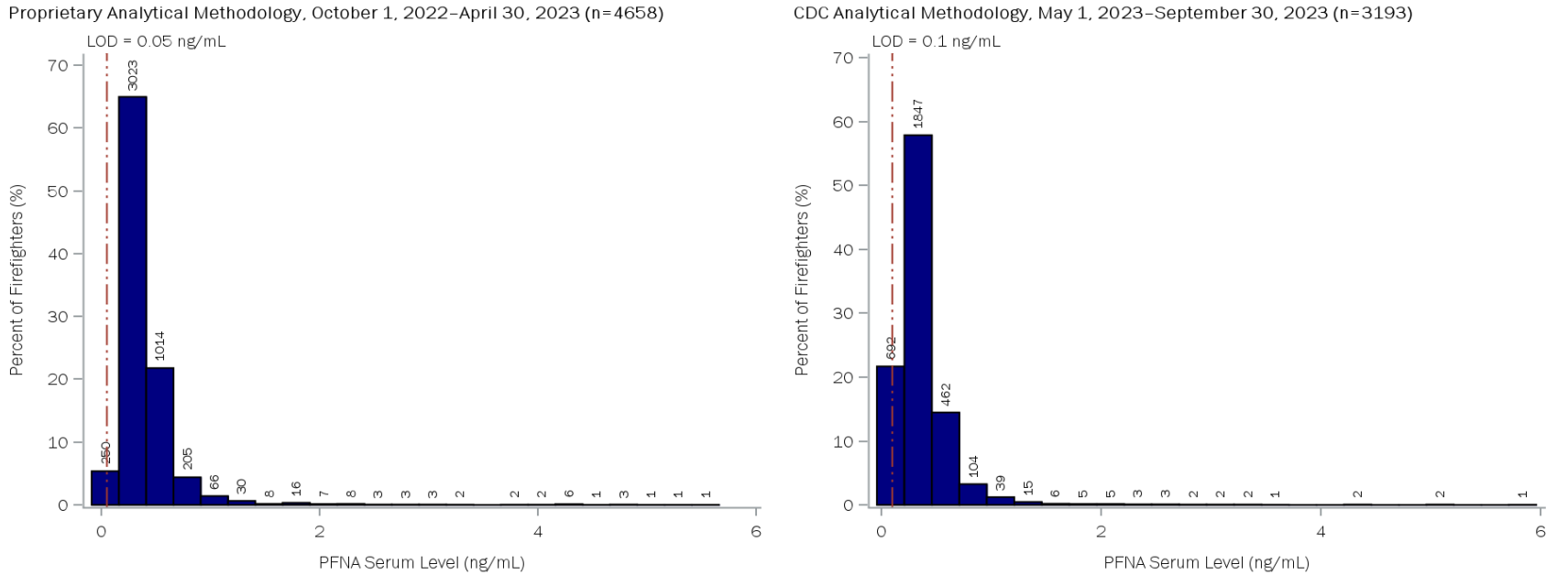
The distribution of values equal to 15 ng/mL or less is displayed in the histogram. There were two values above 15 ng/mL.

The number of records below the limit of detection (LOD)=23. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 13. Percent Distribution of PFNA Analytical Results Among Participating DoD Firefighters, October 1, 2022–September 30, 2023



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

The distribution of values equal to 6 ng/mL or less is displayed in the histograms. There were three values in proprietary and one value in CDC analytical methodology above 6 ng/mL.

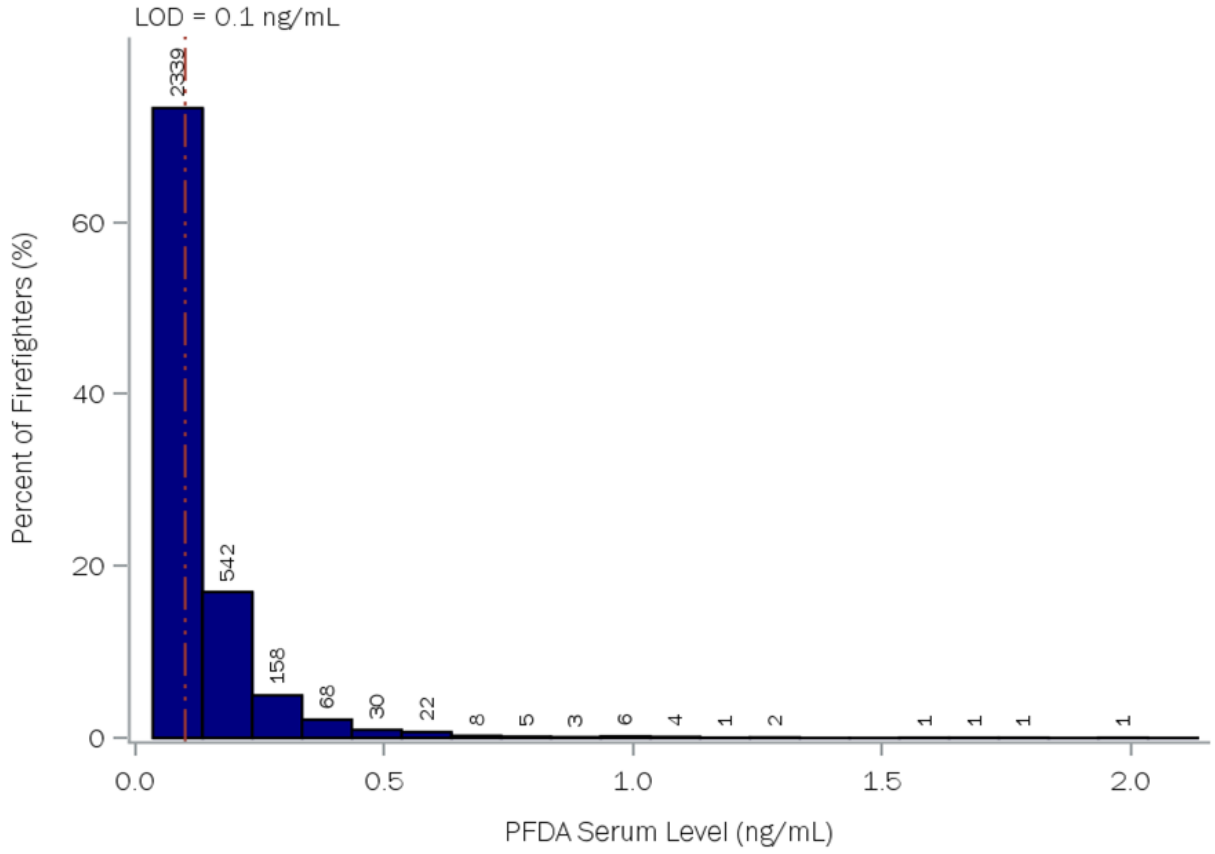
Proprietary methodology had 29 test values below limit of detection (LOD). The LOD is 0.05 ng/mL for proprietary methodology.

CDC analytical methodology had 73 test values below limit of detection (LOD). The LOD is 0.1 ng/mL for CDC analytical methodology.

PFAS values in proprietary analytical methodology are not comparable to those obtained by the CDC from the general population and reported in NHANES, whereas, values in CDC analytical methodology are directly comparable to values reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 14. Percent Distribution of PFDA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

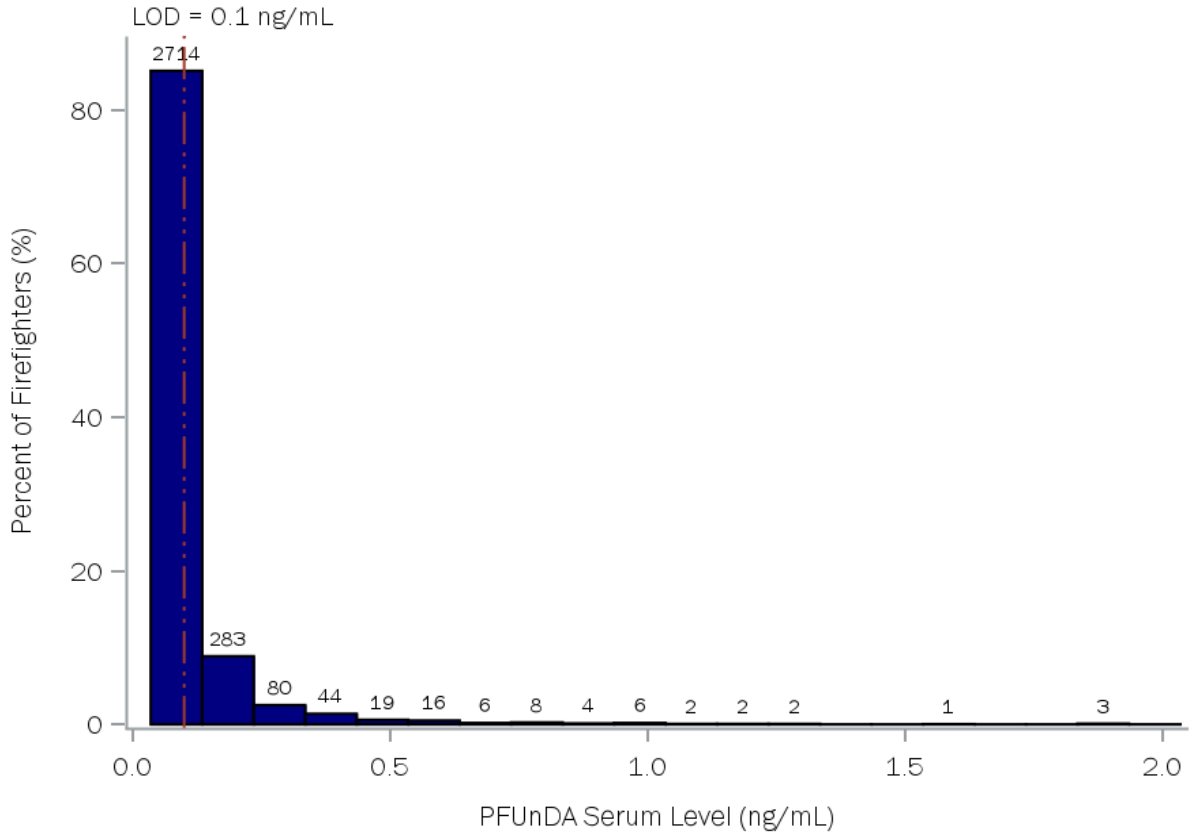
The distribution of values equal to 2 ng/mL or less is displayed in the histograms. There was one value above 2 ng/mL.

The number of records below the limit of detection (LOD)=1780. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 15. Percent Distribution of PFUnDA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

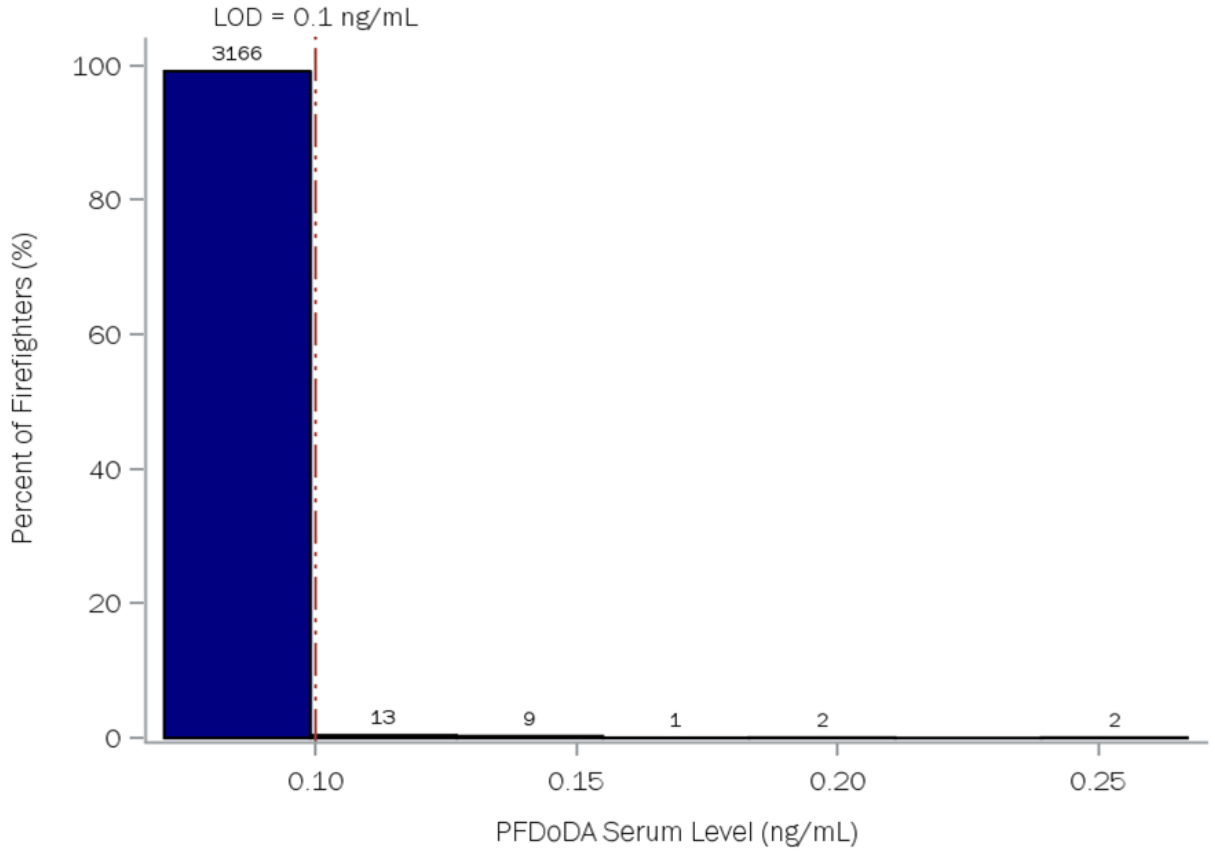
The distribution of values equal to 2 ng/mL or less is displayed in the histograms. There were three values above 2 ng/mL.

The number of records below the limit of detection (LOD)=2419. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 16. Percent Distribution of PFDoDA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3193)



Data Source: LabCorp.

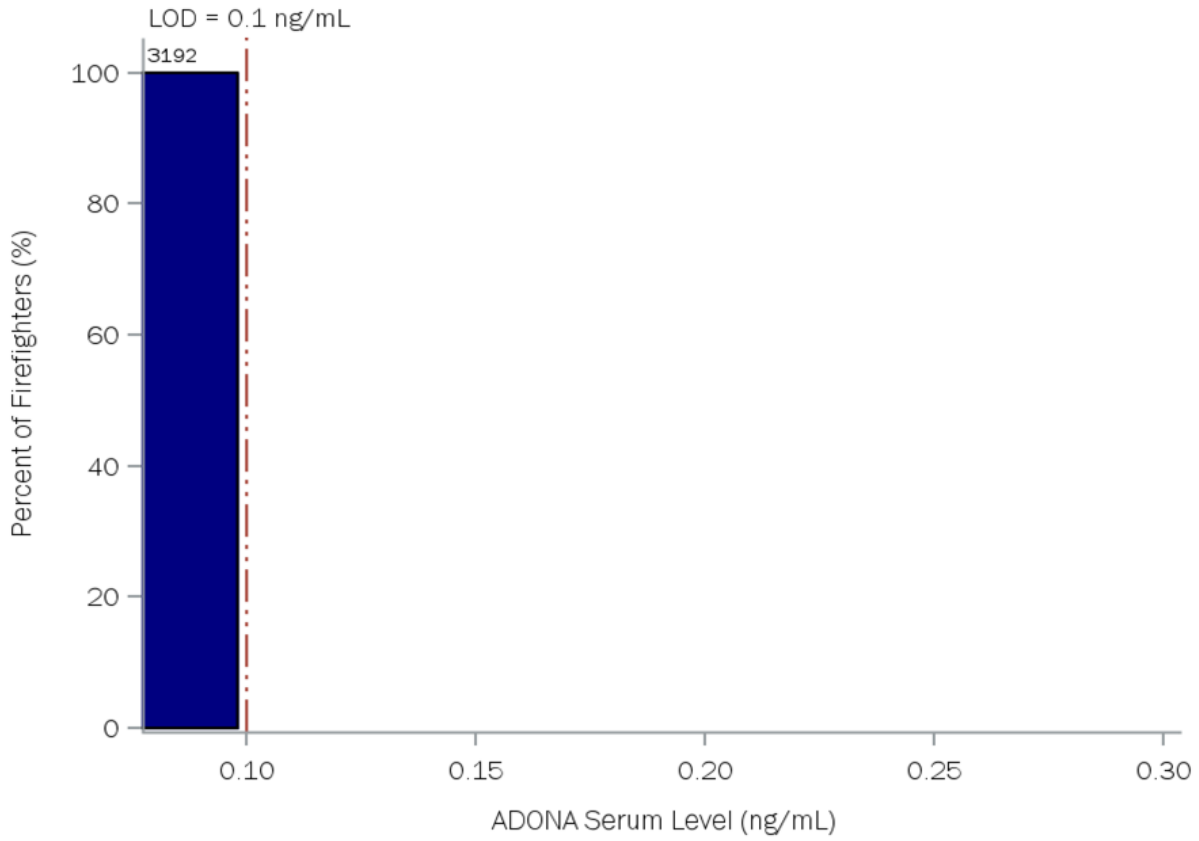
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=3166. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 17. Percent Distribution of ADONA Analytical Results Among Participating DoD Firefighters Using CDC Analytical Methodology, May 1, 2023–September 30, 2023 (n=3192)



Data Source: LabCorp.

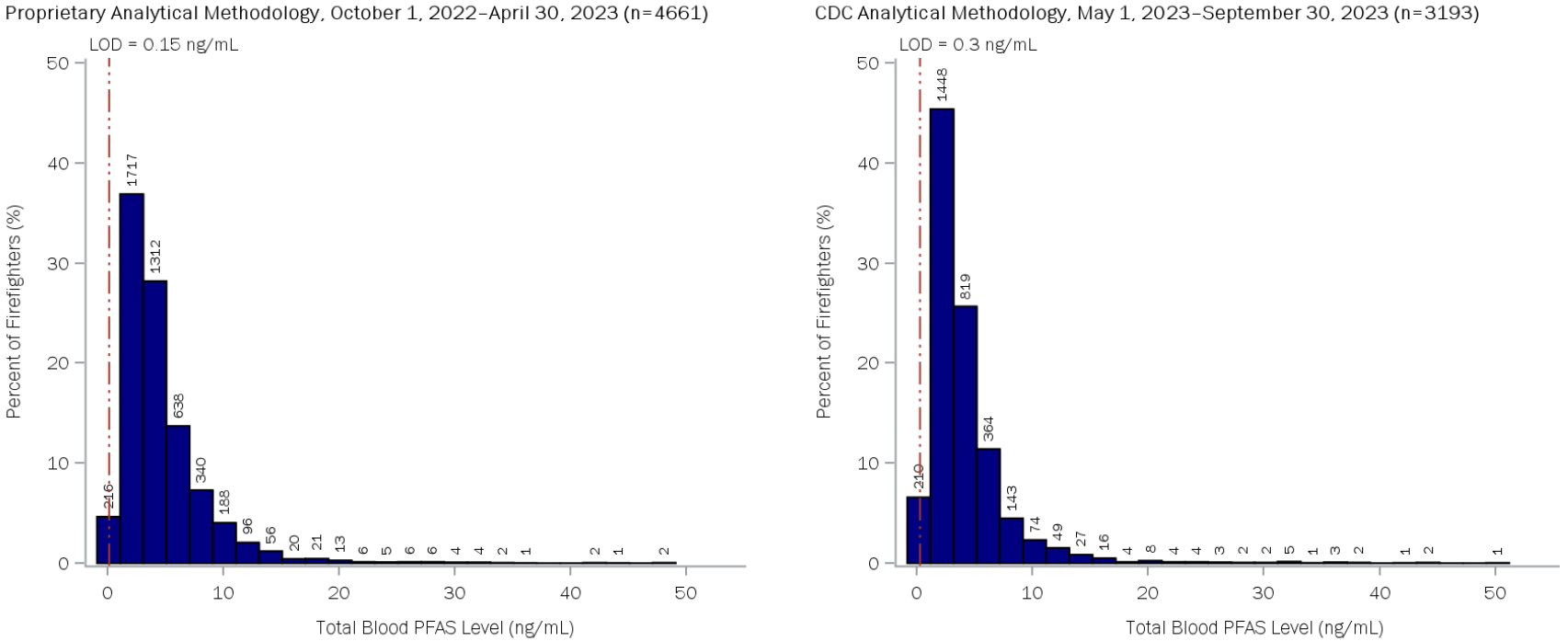
Figure includes service members (SMs) and civilian firefighters.

The number of records below the limit of detection (LOD)=3192. The LOD is 0.1 ng/mL.

The CDC analytical methodology, used to assess blood PFAS levels in firefighters after May 1, 2023, is directly comparable to those obtained by the CDC from the general population and reported in NHANES.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Figure 18. Percent Distribution of Total Blood PFAS Level Analytical Results Among Participating DoD Firefighters, October 1, 2022–September 30, 2023



Data Source: LabCorp.

Figure includes service members (SMs) and civilian firefighters.

The distribution of values equal to 50 ng/mL or less is displayed in the histograms. There were six values in proprietary and one value in CDC analytical methodology above 50 ng/mL.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 12, 2024.

Age and Sex Analyses

Table 3. Participating DoD Firefighters Tested for PFAS by Age Group, FY 2023 (October 1, 2022–September 30, 2023)

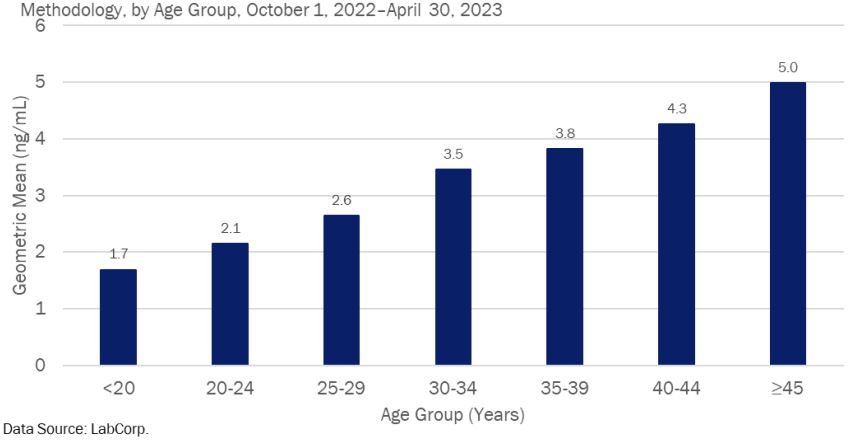
Age Group (Years)	Total Participants Tested	Percent (%)
<20	146	1.9
20-24	1094	14.0
25-29	1038	13.3
30-34	1146	14.6
35-39	1301	16.6
40-44	1223	15.6
≥ 45	1884	24.1
Total	**7832**	**100**

Data Source: LabCorp.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

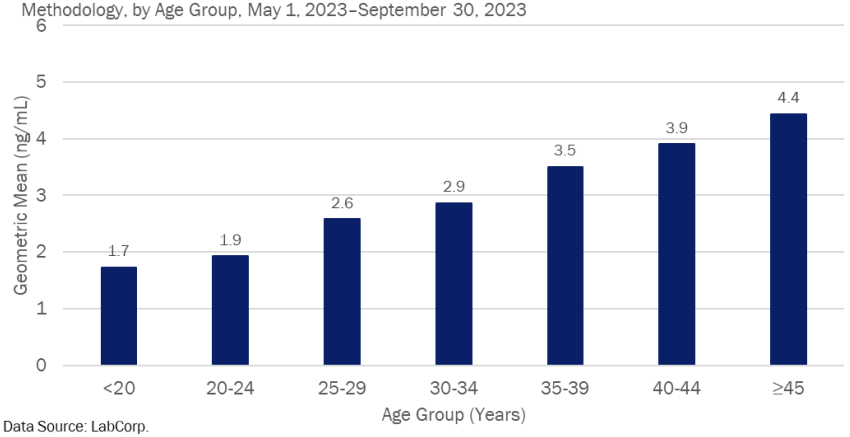
Geometric Means of Total Blood PFAS Level by Age Group

Figure 19a. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Age Group, October 1, 2022–April 30, 2023



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

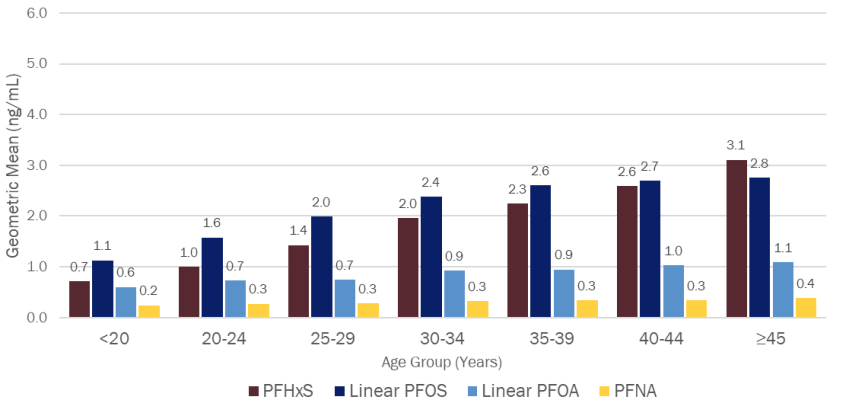
Figure 19b. Geometric Mean of Total Blood PFAS Level Using CDC Analytical Methodology, by Age Group, May 1, 2023–September 30, 2023



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

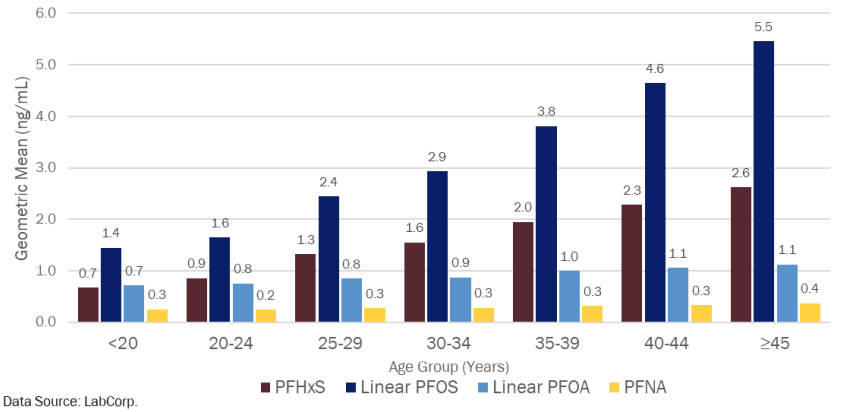
Geometric Means of PFHxS, Linear PFOS and PFOA isomers, and PFNA by Age Group

Figure 20a. Geometric Means of PFAS Analytes Using Proprietary Analytical Methodology, by Age Group, October 1, 2022–April 30, 2023



Data Source: LabCorp.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Figure 20b. Geometric Means of PFAS Analytes Using CDC Analytical Methodology, by Age Group, May 1, 2023–September 30, 2023



Data Source: LabCorp.
Linear PFOS levels measured in CDC analytical method are not comparable to that measured using proprietary methodology.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Table 4. Participating DoD Firefighters Tested for PFAS by Sex, FY 2023 (October 1, 2022–September 30, 2023)

Sex	Total Participants Tested	Percent (%)
Female	286	4.1
Male	6669	95.9
Total*	**6955**	**100**

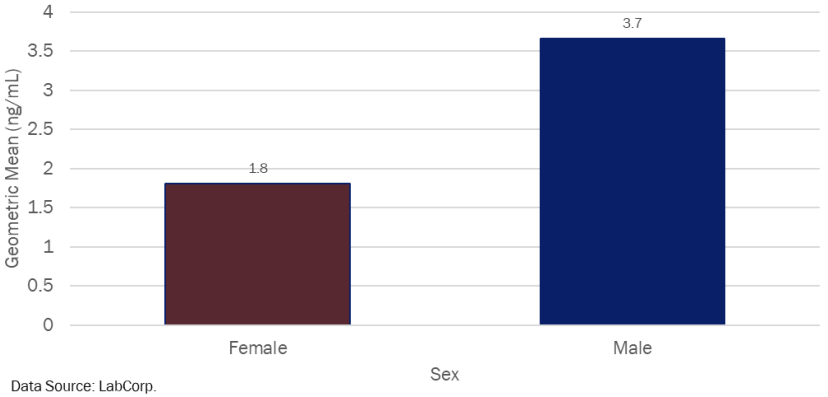
Data Source: LabCorp.

*Data does not include observations with missing sex (n=877).

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

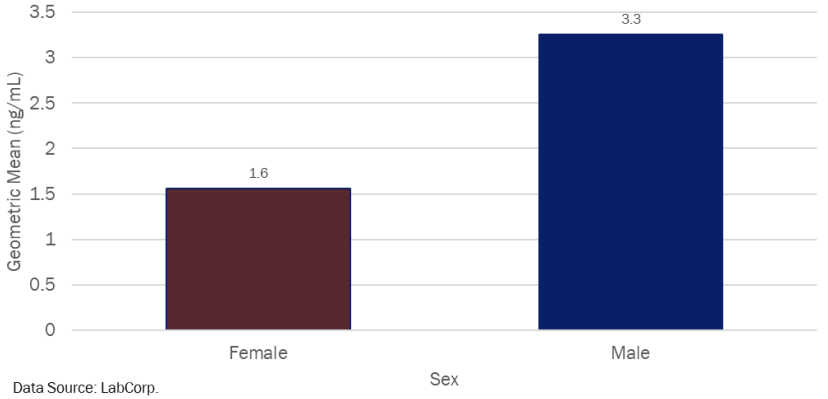
Geometric Means of Total Blood PFAS Level by Sex

Figure 21a. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Sex, October 1, 2022–April 30, 2023



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

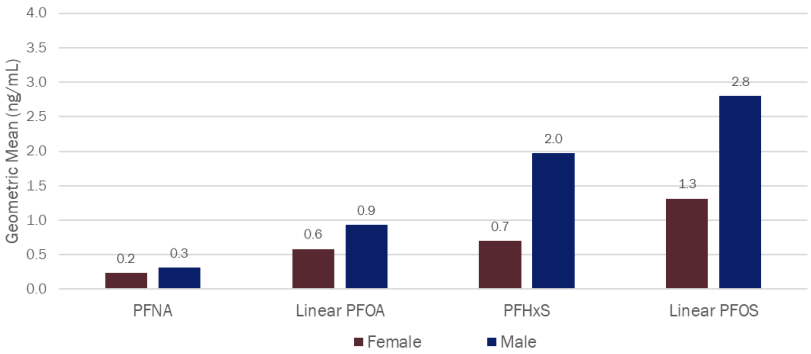
Figure 21b. Geometric Mean of Total Blood PFAS Level Using CDC Analytical Methodology, by Sex, May 1, 2023–September 30, 2023



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

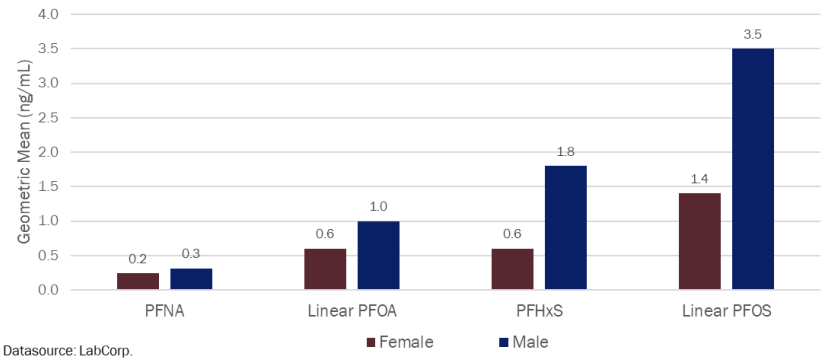
Geometric Means of PFHxS, Linear PFOS and PFOA isomers, and PFNA by Sex

Figure 22a. Geometric Mean of PFAS Analytes Using Proprietary Analytical Method, by Sex, October 1, 2022–April 30, 2023



Datasource: LabCorp.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

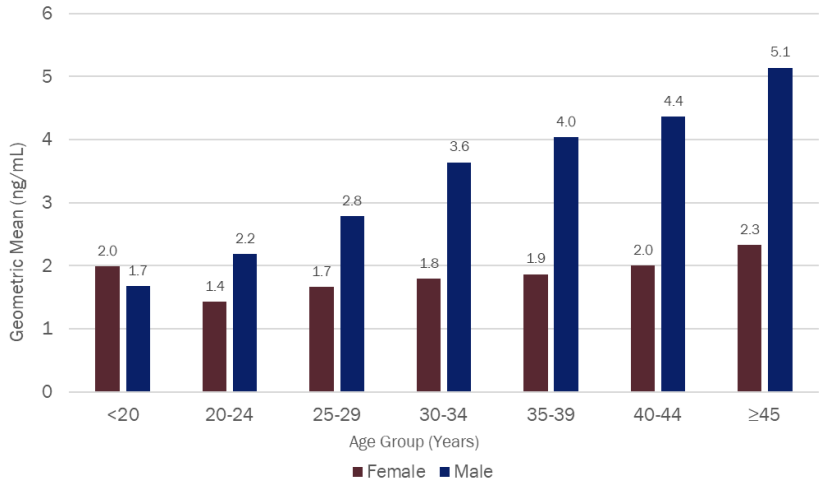
Figure 22b. Geometric Mean of PFAS Analytes Using CDC Analytical Method, by Sex, May 1, 2023–September 30, 2023



Datasource: LabCorp.
Linear PFOS levels measured in CDC analytical method are not comparable to that measured using proprietary methodology.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

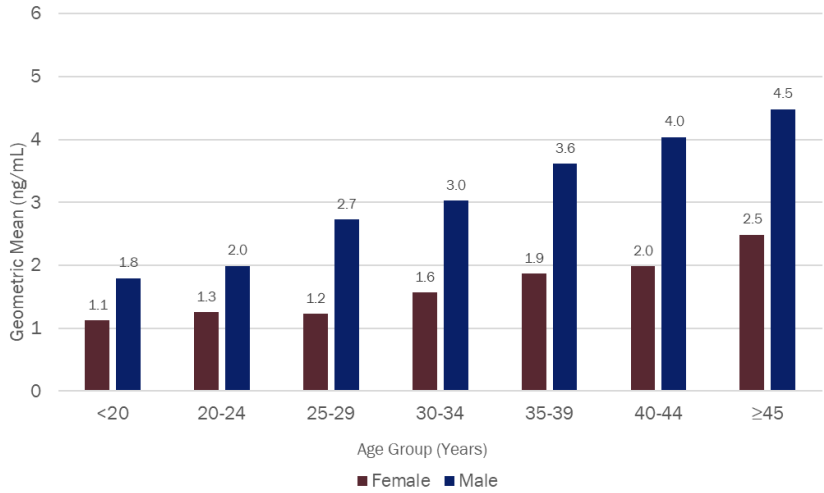
Geometric Means of Total Blood PFAS Level by Age Group and Sex

Figure 23a. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Sex and Age Group, October 1, 2022–April 30, 2023



Datasource: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

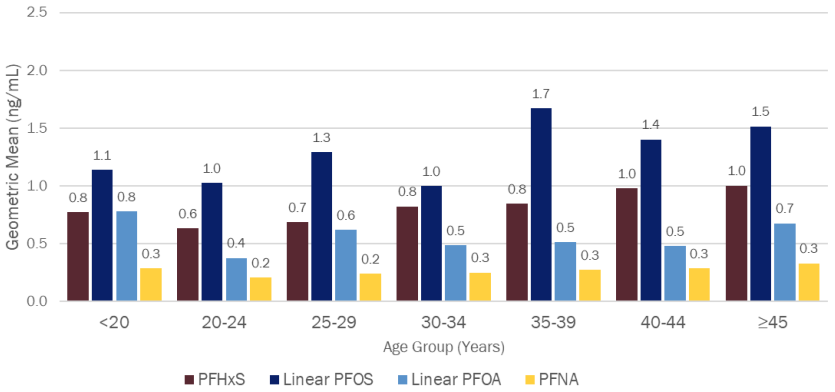
Figure 23b. Geometric Mean of Total Blood PFAS Level Using CDC Analytical Methodology, by Sex and Age Group, May 1, 2023–September 30, 2023



Datasource: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

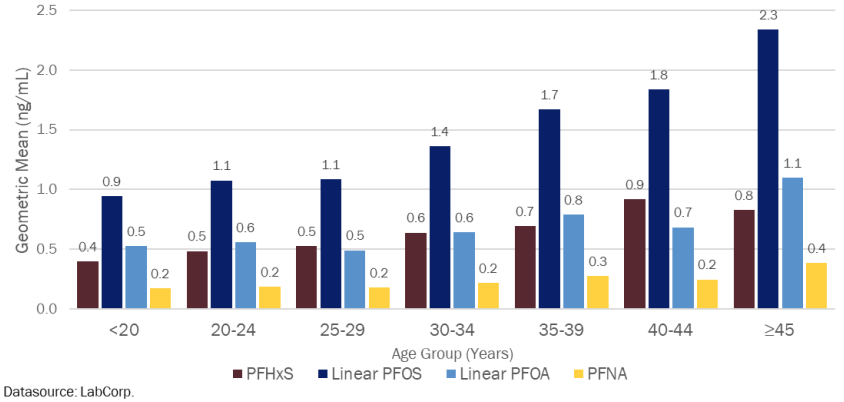
Geometric Means of PFHxS, Linear PFOS and PFOA isomers, and PFNA Among Females by Age Group

Figure 24a. Geometric Mean of PFAS Analytes Using Proprietary Analytical Methodology Among Females by Age Group, October 1, 2022–April 30, 2023



Datasource: LabCorp.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

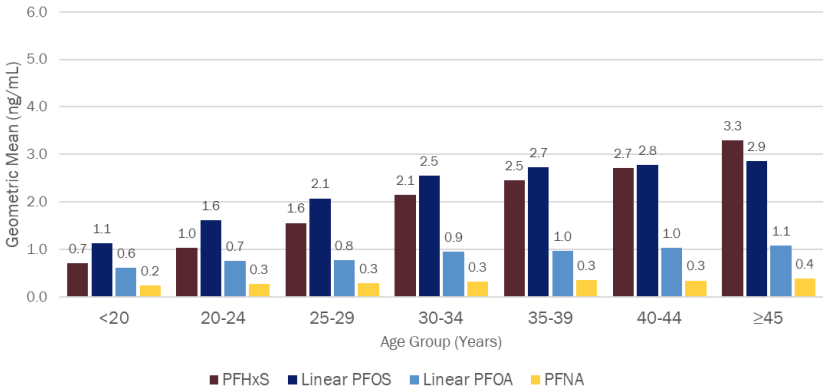
Figure 24b. Geometric Mean of PFAS Analytes Using CDC Analytical Methodology Among Females by Age Group, May 1, 2023–September 30, 2023



Datasource: LabCorp.
Linear PFOS levels measured in CDC analytical method are not comparable to that measured using proprietary methodology.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

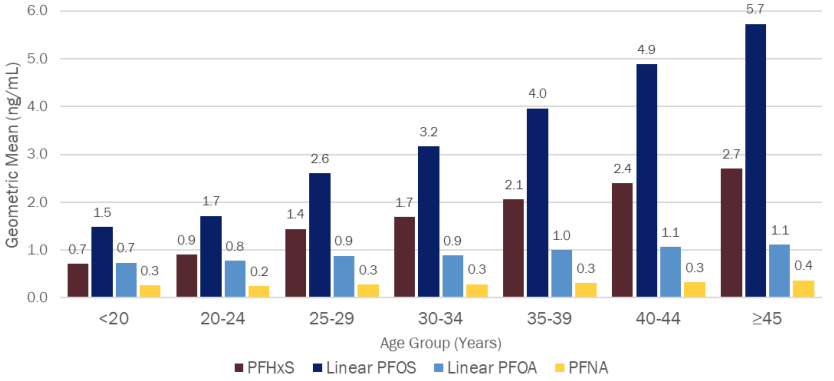
Geometric Means of PFHxS, Linear PFOS and PFOA isomers, and PFNA Among Males by Age Group

Figure 25a. Geometric Mean of PFAS Analytes Using Proprietary Analytical Methodology Among Males by Age Group, October 1, 2022–April 30, 2023



Datasource: LabCorp.
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Figure 25b. Geometric Mean of PFAS Analytes Using CDC Analytical Methodology Among Males by Age Group, May 1, 2023–September 30, 2023



Datasource: LabCorp.
Linear PFOS levels measured in CDC analytical method are not comparable to that measured using proprietary methodology.
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Trend Analysis by Analyte - Overall

Table 5. Univariate Statistics for PFAS Blood Testing Using Proprietary Analytical Methodology Among Participating DoD Firefighters with Records in FY 2021, FY 2022 and FY 2023

	FY 2021		FY 2022		FY 2023	
Analyte	Total Valid Tests	Geometric Mean (ng/mL)[a]	Total Valid Tests	Geometric Mean (ng/mL)[a]	Total Valid Tests	Geometric Mean (ng/mL)[a]
PFBS	1074	*	1066	*	1061	*
PFHpA	1070	*	1062	*	1055	*
PFHxS	1032	3.00 (2.86-3.15)	1042	2.66 (2.53-2.80)	1061	2.40 (2.28-2.53)
PFNA	1067	0.43 (0.41-0.44)	1059	0.37 (0.35-0.38)	1059	0.35 (0.33-0.36)
Linear PFOA	1074	1.18 (1.13-1.24)	1064	1.06 (1.00-1.11)	1061	0.96 (0.91-1.02)
Linear PFOS	1070	3.30 (3.15-3.46)	1066	2.95 (2.81-3.10)	1060	2.67 (2.53-2.81)
Total Blood PFAS Level[b]	**1074**	**4.67 (4.46-4.88)**	**1066**	**4.26 (4.07-4.45)**	**1061**	**4.05 (3.88-4.23)**

Data Source: LabCorp.

[a]95% Confidence Limits were calculated for the geometric mean.

[b]Total PFAS Blood Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.

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

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Discussion

Adoption of CDC Analytical Methodology

In May of 2023, the DoD began using the CDC analytical methodology and an expanded PFAS target analyte list. The purpose of these changes in the blood PFAS testing protocol was to provide a more robust assessment of DoD firefighters' PFAS exposure levels, and to allow for a direct comparison of firefighter blood PFAS levels with those reported by the CDC for the general population. The use of the CDC analytical methodology removes differences in approaches that prevented comparison of prior firefighter blood PFAS levels with those from the public.

At the DoD's request, the NMS lab compared their proprietary methodology with the CDC analytical methodology, when assessing four PFAS analytes (PFHxS, PFNA, and the linear isomers of PFOA and PFOS). This comparison used split blood samples from 212 firefighters.[7] NMS's proprietary analytical methodology (used prior to May 1, 2023, to assess blood levels of six PFAS analytes (PFHxS, PFNA, PFBS, PFHpA, and the linear isomers of PFOA and PFOS)) demonstrated reasonably similar results to those obtained from the CDC analytical methodology for three of the four analytes (PFHxS, PFNA, and the linear isomer of PFOA). These three PFAS analytes were then used in trend analyses over FYs 2021–2023. For these PFAS analytes, the bias measured between the proprietary and CDC analytical methodologies was -0.098 ng/mL (-3.038%), -0.004 ng/mL (-0.937%), and 0.039 (2.63%), respectively.[7] From the NMS study, neither analytical method detected blood PFBS nor PFHpA levels exceeded the applicable LOD in 40% or more of the firefighters tested. As a result, neither of these analytes were further evaluated in the validation test.

The CDC analytical methodology generally reported a higher concentration of the linear isomer of PFOS in split samples of firefighter blood. NMS suggested that this results from coelution of the linear and branched isomers of PFOS: 1-methyl-perfluoroheptanesulfonic acid (1M-PFHpS) in the CDC analytical method. The CDC is aware of this coelution but noted that Total PFOS levels reported in firefighter blood should be accurate.[7] The result of the proprietary method analysis of the linear isomer of PFOS should not be compared to CDC's analytical result for the linear isomer of PFOS because the presence of 1M-PFHpS confounds the CDC analysis for this isomer. While the linear isomer of PFOS is not comparable, total PFOS levels measured in DoD firefighters can be compared with the general population.

Comparison of DoD Firefighters and CDC General Population

Table 2 compares the proprietary and CDC analytical methodologies in the analysis of firefighter blood PFAS levels in FY 2023. The proprietary analytical methodology was used in the first half of FY 2023 (October 1, 2022–April 30, 2023) to assess approximately 4,650 DoD firefighter blood PFAS levels for 6 target analytes (PFBS, PFHpA, PFHxS, PFNA, and the linear isomers of PFOA and PFOS). Consistent with blood PFAS test results from prior years, and with the latest results reported by the CDC for 2017–2018, fewer than 40% of the samples assessed detected either PFBS or PFHpA above the LOD of 0.05 ng/mL. The geometric mean of total PFOS levels in DoD firefighters (geometric mean = 4.42 ng/mL [95% CI: 4.27–4.57 ng/mL]) is similar to that of total PFOS levels in the general population (geometric mean = 4.50 ng/mL [95% CI: 4.15–4.89 ng/mL]).

Additionally, firefighter blood levels of PFHxS, PFNA, and the linear isomers of PFOA and PFOS demonstrated a downward trend over FYs 2021–2023 (Table 5). This could be attributed to DoD policy changes which restrict the use of AFFF containing PFAS; however, these trends may also

reflect general efforts to reduce exposure in the general population. The CDC likewise reported a reduction in the blood PFAS levels measured among the general population.[7]

Blood PFHxS levels in DoD firefighters may be elevated compared to adults in the general population, as indicated by a comparison with CDC data. A comparison of the geometric means and corresponding 95% CIs for blood PFHxS levels in DoD firefighters (FY 2021), with the most recent blood PFHxS levels reported by the CDC for the general population (FY 2017–2018), suggests that PFHxS (geometric mean = 3.00 ng/mL [95% CI: 2.86–3.15 ng/mL]) may be elevated with respect to that observed among persons ≥20 years of age in the general population (geometric mean = 1.11 ng/mL [95% CI: 1.05–1.21]). This comparison is potentially confounded by the few years' difference in specimen collection dates and significant demographic differences between these two populations. Thus, the comparison cannot conclude whether blood PFHxS levels in DoD firefighters are associated with AFFF use or other occupational exposures. Firefighter use of AFFF containing PFAS may not be their only significant occupational exposure to PFAS. Levasseur et al. (2022)[9] noted that firefighters who do not use AFFF in fighting fires appear to have a higher external exposure to PFHxS than their peers who did not fight fires.

There was no significant difference between the geometric mean of blood PFNA levels measured in FY 2021 DoD firefighters (geometric mean = 0.41 ng/mL [95% CI: 0.41–0.42 ng/mL]) and the FY 2017–2018 CDC general population (geometric mean = 0.42 ng/mL [95% CI: 0.37–0.47 ng/mL]). (See Table A3.) However, for these same populations, DoD firefighters had lower blood levels of the linear isomer of PFOA (geometric mean = 1.14 ng/mL [95% CI: 1.11–1.16 ng/mL]) than the CDC general population (geometric mean = 1.36 ng/mL [95% CI: 1.26–1.46 ng/mL]). The difference in linear isomer PFOA blood levels in firefighters (FYs 2021–2022) and the general population (FYs 2017–2018) supports the earlier presumption that significant demographic and collection date differences may be responsible. The current regulatory agency and DoD policies limiting potential PFAS exposures may be responsible for the observed decline in PFAS levels in both study populations. However, the relative contribution of regulatory and DoD policies aimed to lowering DoD firefighter blood PFAS levels is unknown.

Blood levels of MeFOSAA, PFHpS, Total PFOS, Total PFOA, and PFNA measured in DoD firefighters in FY 2023 using the CDC analytical method are either similar to, or slightly less than the blood levels measured in the general population by the CDC in FYs 2017–2018 (Table 2). While these results are somewhat expected, given that blood PFAS levels continue to decline each year, these comparisons are potentially confounded by previously discussed demographic and collection date differences between the DoD and CDC. Continued surveillance with published CDC blood PFAS levels from FYs 2022–2023 will allow for stronger comparisons, when available.

Variation of PFAS Blood Levels by Age, Sex, and Fiscal Year

Consistent with the results of recent research publications, older DoD firefighters tend to have higher blood PFAS levels than younger firefighters (Figures 19a, 19b, 20a, and 20b).[6,10–12] This is likely due to the very long half-lives of some target PFAS analytes in the human body, which result in the accumulation of PFAS levels over time.

Also consistent with prior published research, the geometric mean of total PFAS (sum of PFHxS, linear PFOA and PFNA) detected using the proprietary analytical method, demonstrated a linear increase with firefighter age. More specifically, the highest geometric mean occurred among those ≥45 years of age (5.4 ng/mL), and the lowest was observed among those <20 years of age (1.6 ng/mL). Both PFHxS and linear PFOS had the highest geometric means in each age group, as

measured by the proprietary methodology. Whereas, linear PFOS had the highest geometric means in each age group, as measured by the CDC analytical methodology.

Tables 19a, 19b, B1, and B2 demonstrate a clear age dependence for Total PFAS accumulation, which reflects both occupational and nonoccupational PFAS exposures. These findings corroborate recent research.[6,10–13]

Figures 20a and 20b show age-dependent accumulation of individual PFAS analytes. The differences between these two figures are limited to PFOS and are attributable to the two different analytical methodologies used. The CDC analytical method's assessment of the linear isomer of PFOS is biased upward by the presence of the PFOS branched isomer, 1M-PFHpS. For the remaining analytes, the values displayed in the two figures are similar.

The accumulation of target PFAS analytes in humans shows a clear sexual dimorphism. Individual PFAS analytes tend to differentially accumulate in male and female firefighters, with Total PFAS levels accumulating to a much greater degree in males than females. It is important to note that females comprise a very small fraction (4%) of DoD firefighters in this report, and information relating to female firefighters' health status is not available. Health status information (such as pregnancy, childbirth, lactation, and menstruation) can significantly increase PFAS elimination, resulting in lower blood PFAS levels for women than men.[4,5,10] Regardless of the analytical method used or the year of analysis, male DoD firefighters appear to accumulate two to three times more PFHxS and the linear isomer of PFOS than females in all age groups. Male firefighters also appear to accumulate about 30% more linear isomer of PFOA than females in all age groups. Similarly, while there is much less accumulation of PFNA than the other target PFAS analytes in humans overall, male firefighters still tend to accumulate approximately 30% more PFNA than female firefighters.

Although DoD firefighter blood levels of linear PFOS appear to increase in FY 2023 using the CDC analytical methodology compared to prior years using the proprietary analytical methodology (FY 2021–2022 and the first half of FY 2023); this is likely due to contamination of the linear PFOS sample with branched PFOS isomers.[7]

Sources of PFAS for DoD Firefighters

A very small fraction of DoD firefighters used AFFF in fighting fires over the last few years. Specifically, there have been fewer than 10 events across the globe where DoD firefighters used PFAS-containing AFFF for operational responses. Data that identify these specific firefighters were unavailable for this current report. Typically, firefighters respond to fires as part of a group or unit.

Each firefighter within a group/unit is expected to have somewhat similar blood PFAS levels, with higher group/unit blood PFAS levels potentially attributable to use of PFAS-containing AFFF during firefighting activities. Individual firefighter results with significantly higher blood PFAS levels than any of their group/unit peers may be due to nonoccupational sources of exposure. Current regulatory agency and DoD policies limiting potential PFAS exposures may be responsible for the observed decline in PFAS levels, in both the general population and DoD firefighters. The relative contribution of regulatory and DoD policies to lowering DoD firefighter blood PFAS levels is unknown.

Conclusions

The DoD firefighter blood PFAS analytical results do not allow determination of the magnitude, timing of exposure (frequency and duration), or likely source of PFAS exposures. Annual surveillance reports track trend levels of PFAS in DoD firefighter serum. A limited trend analysis of firefighters sampled in FYs 2021–2023 shows a downward slope in total and individual PFAS serum levels.

Limitations

The available records do not contain any information about the individual's risk for exposure to PFAS (e.g., job duties, length of employment, or contact with AFFF). Data cleaning was conducted to retain records for DoD firefighters only. However, while this report references "firefighters," the EDC could not confirm an individual's occupation for those tested. As a result, this report may include blood PFAS analyses from individuals in other occupations or beneficiaries who were tested for blood PFAS, based on potential exposure concerns.

The EDC receives PFAS testing records directly from LabCorp. The categorization and validation of firefighter blood PFAS data are reliant on these records. In response, the EDC used validation steps to reduce potential misclassification errors in the available data. The data presented in this report, and the conclusions derived from the EDC's analysis, are based on FY 2021 through FY 2023 data collected in this manner. A statistical trend analysis yielded suggestive results; however, more data points would be needed to draw more solid conclusions.

Contact Us

Since 2006, the EpiData Center (EDC) has provided timely, actionable data surveillance and analysis for the Department of the Navy and Department of Defense in support of military health and readiness. The EDC's epidemiological and technical expertise informs a comprehensive, evidence-based suite of public health products regarding reportable and emerging infections, healthcare-associated infections, delivery of care challenges, patient safety, behavioral and operational health, exposure and injury analysis, and application development and data systems support.

For questions about this report, or to inquire about project support, please contact the EDC at usn.hampton-roads.navmcpubhlthcenpors.list.nmcphc-epi-plls@health.mil.

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Appendix A: Overall PFAS Metrics FYs 2021–2022

Table A1. Participating DoD Firefighters Tested for PFAS by Service Branch, FY 2021 (October 1, 2020–September 30, 2021)

Service Branch	Total Participants Tested	Percent (%)
Air Force	3636	51.2
Army	1475	20.8
Marine Corps	709	10.0
Navy	1256	17.7
Unknown/Other	24	0.3
Total	7100	100.0

Data Source: LabCorp.

Includes service members (SMs) and civilian firefighters.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 11, 2024.

Table A2. Participating DoD Firefighters Tested for PFAS by Service Branch, FY 2022 (October 1, 2021–September 30, 2022)

Service Branch	Total Participants Tested	Percent (%)
Air Force	4472	53.6
Army	1709	20.5
Marine Corps	787	9.4
Navy	1365	16.4
Unknown/Other	12	0.1
Total	8345	100.0

Data Source: LabCorp.

Includes service members (SMs) and civilian firefighters.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 11, 2024.

Table A3. PFAS Laboratory Testing Among Participating DoD Firefighters, FY 2021 (October 1, 2020–September 30, 2021)

Analyte	Total Valid Tests	Below Limit of Detection (%)[a]	Geometric Mean (ng/mL)[b]	95th Percentile (ng/mL)[c]	No. of Firefighters >95th Percentile	Maximum Value (ng/mL)
PFBS	7364	96.85	*	<LOD	232	0.7
PFHpA	7324	82.13	*	0.10	363	1
PFHxS	7027	0.14	2.87 (2.81-2.93)	10.00	225	340
PFNA	7307	0.51	0.41 (0.41-0.42)	0.99	353	8.8
Linear PFOA	7364	3.82	1.14 (1.11-1.16)	2.90	353	24
Linear PFOS	7348	0.84	3.07 (3.01-3.12)	11.00	294	150

Data Source: LabCorp.

[a] Percent of samples with a value below the limit of detection (0.05 ng/mL).

[b] 95% Confidence Limits were calculated for the geometric mean.

[c] Represents the point at which 5% of the serum samples in the cohort exceeds that value.

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

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

Includes only valid test results.

All result values are in ng/mL.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table A4. PFAS Laboratory Testing Among Participating DoD Firefighters, FY 2022 (October 1, 2021–September 30, 2022)

Analyte	Total Valid Tests	Below Limit of Detection (%)[a]	Geometric Mean (ng/mL)[b]	95th Percentile (ng/mL)[c]	No. of Firefighters >95th Percentile	Maximum Value (ng/mL)
PFBS	8645	97.67	*	<LOD	201	0.83
PFHpA	8590	84.28	*	<LOD	428	1.9
PFHxS	8450	0.27	2.30 (2.26-2.35)	9.60	421	100
PFNA	8562	0.55	0.35 (0.35-0.36)	0.84	424	8.2
Linear PFOA	8638	5.77	1.00 (0.98-1.02)	2.70	400	150
Linear PFOS	8647	0.77	2.67 (2.62-2.71)	9.70	427	63

Data Source: LabCorp.

[a] Percent of samples with a value below the limit of detection (0.05 ng/mL).

[b] 95% Confidence Limits were calculated for the geometric mean.

[c] Represents the point at which 5% of the serum samples in the cohort exceeds that value.

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

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

Includes only valid test results.

All result values are in ng/mL.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Appendix B: PFAS Age Distribution FYs 2021–2023

Table B1. Participating DoD Firefighters Tested for PFAS by Age Group, FY 2021 (October 1, 2020–September 30, 2021)

Age Group (Years)	Total Participants Tested	Percent (%)
<20	88	1.2
20-24	771	10.9
25-29	885	12.5
30-34	1022	14.4
35-39	1309	18.4
40-44	1159	16.3
≥ 45	1866	26.3
Total	**7100**	**100**

Data Source: LabCorp.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

Table B2. Participating DoD Firefighters Tested for PFAS by Age Group, FY 2022 (October 1, 2021–September 30, 2022)

Age Group (Years)	Total Participants Tested	Percent (%)
<20	124	1.5
20-24	1013	12.1
25-29	1078	12.9
30-34	1240	14.9
35-39	1522	18.2
40-44	1362	16.3
≥ 45	2006	24
Total	**8345**	**100**

Data Source: LabCorp.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

Table B3. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2021 (October 1, 2020–September 30, 2021)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	65	0.94 (0.82-1.08)	4.2	90	0.32 (0.28-0.37)	4.8
20-24	687	1.49 (1.42-1.57)	26	778	0.33 (0.32-0.34)	2.4
25-29	848	2.08 (1.98-2.18)	22	896	0.35 (0.34-0.36)	2.5
30-34	1007	2.64 (2.51-2.77)	30	1050	0.39 (0.38-0.40)	3.9
35-39	1325	3.18 (3.06-3.31)	34	1352	0.43 (0.42-0.44)	7.5
40-44	1178	3.37 (3.22-3.52)	340	1200	0.44 (0.42-0.45)	8.8
≥ 45	1917	3.84 (3.70-3.98)	52	1941	0.47 (0.45-0.48)	8.6
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	91	0.74 (0.61-0.88)	2.5	91	1.26 (1.09-1.45)	4.3
20-24	790	0.88 (0.84-0.92)	4	790	2.10 (2.01-2.20)	35
25-29	910	0.94 (0.89-0.99)	24	908	2.76 (2.64-2.90)	26
30-34	1056	1.13 (1.08-1.19)	9.2	1056	3.08 (2.92-3.24)	53
35-39	1360	1.20 (1.15-1.25)	12	1357	3.44 (3.30-3.58)	44
40-44	1209	1.23 (1.17-1.29)	21	1206	3.42 (3.26-3.59)	65
≥ 45	1948	1.29 (1.25-1.34)	24	1940	3.37 (3.24-3.50)	150

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table B4. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2022 (October 1, 2021–September 30, 2022)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	116	0.72 (0.66-0.78)	3.5	123	0.26 (0.24-0.28)	1
20-24	1001	1.07 (1.03-1.11)	45	1041	0.29 (0.27-0.29)	2.5
25-29	1091	1.67 (1.60-1.75)	19	1108	0.31 (0.30-0.32)	1.4
30-34	1258	2.10 (2.01-2.21)	38	1275	0.34 (0.33-0.35)	3.4
35-39	1534	2.65 (2.54-2.76)	40	1552	0.37 (0.36-0.38)	6.1
40-44	1398	2.86 (2.74-2.99)	57	1401	0.37 (0.36-0.38)	8.2
≥ 45	2052	3.46 (3.33-3.60)	100	2062	0.42 (0.41-0.43)	8
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	126	0.54 (0.44-0.65)	2.1	126	1.23 (1.12-1.35)	4.3
20-24	1061	0.72 (0.68-0.76)	6.2	1061	1.76 (1.71-1.82)	35
25-29	1117	0.85 (0.80-0.90)	5.7	1117	2.36 (2.26-2.46)	63
30-34	1287	0.94 (0.89-1.00)	8	1288	2.66 (2.55-2.79)	49
35-39	1564	1.09 (1.04-1.14)	11	1567	3.00 (2.89-3.12)	49
40-44	1410	1.11 (1.06-1.16)	12	1413	2.92 (2.79-3.05)	34
≥ 45	2073	1.21 (1.17-1.26)	150	2075	3.19 (3.08-3.30)	47

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table B5. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2023 (October 1, 2022–April 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
< 20	69	0.71 (0.62-0.81)	3.3	70	0.24 (0.22-0.27)	0.73
20-24	617	1.00 (0.95-1.05)	11	617	0.27 (0.26-0.28)	1.2
25-29	633	1.43 (1.34-1.52)	16	637	0.28 (0.27-0.29)	1.4
30-34	689	1.96 (1.85-2.09)	36	692	0.32 (0.31-0.33)	3.3
35-39	764	2.25 (2.11-2.40)	29	768	0.34 (0.33-0.36)	4.4
40-44	735	2.59 (2.42-2.77)	46	737	0.34 (0.33-0.36)	5.6
≥ 45	1135	3.11 (2.95-3.28)	130	1137	0.38 (0.37-0.40)	8.1
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
< 20	70	0.66 (0.47-0.76)	3	70	1.13 (0.97-1.31)	6.9
20-24	617	0.73 (0.68-0.78)	6.8	617	1.58 (1.50-1.65)	30
25-29	638	0.74 (0.69-0.80)	3.4	638	1.99 (1.88-2.10)	27
30-34	693	0.93 (0.86-1.00)	13	693	2.38 (2.24-2.53)	24
35-39	768	0.95 (0.88-1.02)	8.3	768	2.60 (2.45-2.76)	36
40-44	737	1.03 (0.97-1.11)	23	736	2.69 (2.52-2.88)	22
≥ 45	1138	1.09 (1.03-1.16)	24	1137	2.76 (2.63-2.90)	91

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters..

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table B6. PFAS Laboratory Testing Among Participating DoD Firefighters Using CDC Analytical Methodology by Age Group, FY 2023 (May 1, 2023–September 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
< 20	74	0.67 (0.60-0.75)	3.4	74	0.25 (0.22-0.29)	3.1
20-24	489	0.86 (0.81-0.91)	7.8	490	0.24 (0.23-0.26)	1.4
25-29	417	1.32 (1.23-1.43)	19	417	0.27 (0.26-0.28)	1.9
30-34	461	1.55 (1.43-1.68)	31	461	0.28 (0.27-0.30)	3.6
35-39	527	1.95 (1.80-2.11)	30	527	0.31 (0.30-0.33)	1.4
40-44	485	2.28 (2.12-2.46)	34	486	0.33 (0.31-0.35)	3.2
≥ 45	738	2.63 (2.44-2.82)	62	738	0.37 (0.35-0.39)	5.8
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
< 20	74	0.72 (0.64-0.80)	3.6	74	1.45 (1.28-1.64)	12
20-24	490	0.75 (0.73-0.78)	4.4	490	1.65 (1.56-1.74)	18
25-29	417	0.85 (0.81-0.89)	4.4	417	2.45 (2.27-2.63)	15
30-34	461	0.87 (0.83-0.92)	16	461	2.93 (2.70-3.18)	23
35-39	527	1.00 (0.95-1.05)	8.8	527	3.81 (3.53-4.11)	39
40-44	484	1.06 (1.01-1.11)	7.4	485	4.65 (4.31-5.02)	37
≥ 45	738	1.12 (1.07-1.18)	17	738	5.46 (5.09-5.85)	54

Data Source: LabCorp.

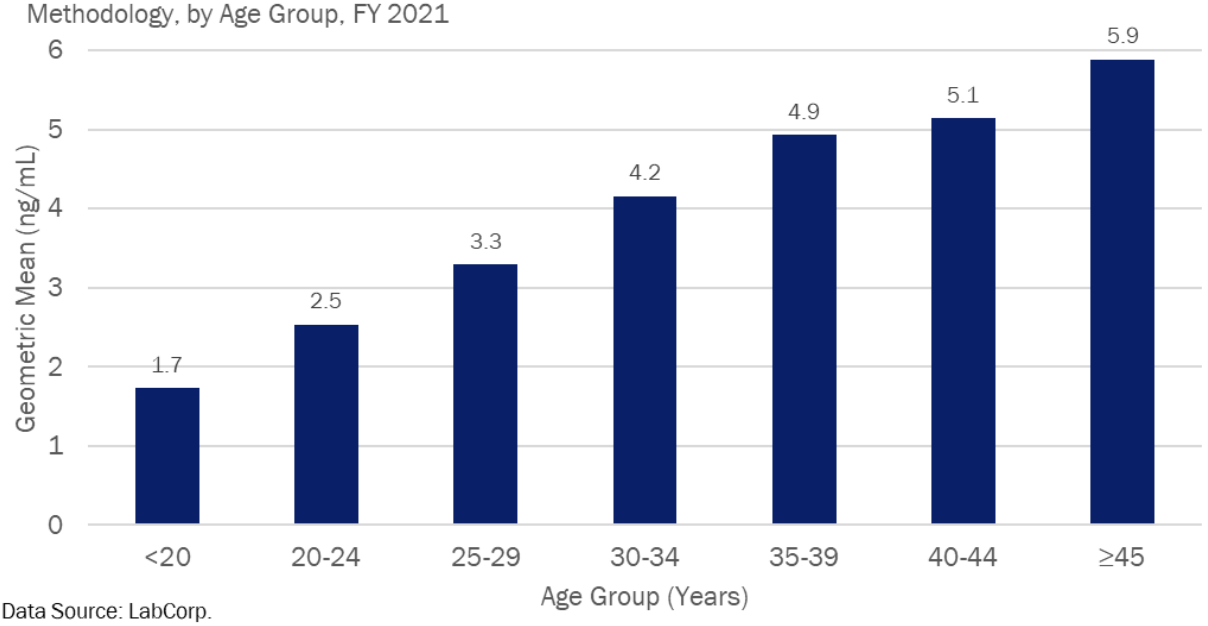
[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

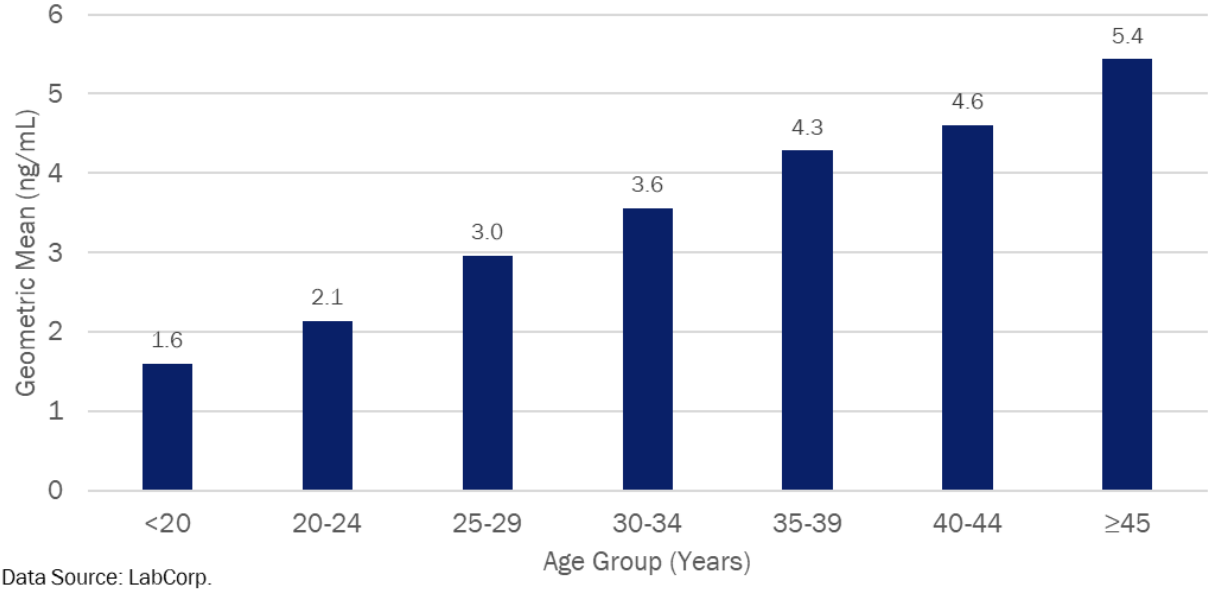
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Figure B1. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Age Group, FY 2021



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Figure B2. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Age Group, FY 2022



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Appendix C: PFAS Sex Distribution FY 2021–FY 2023

Table C1. Participating DoD Firefighters Tested for PFAS by Sex, FY 2021 (October 1, 2020–September 30, 2021)

Sex	Total Participants Tested	Percent (%)
Female	209	3.5
Male	5804	96.5
Total*	**6013**	**100**

*Data does not include observations with missing sex (n=1087).

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

Table C2. Participating DoD Firefighters Tested for PFAS by Sex, FY 2022 (October 1, 2021–September 30, 2022)

Sex	Total Participants Tested	Percent (%)
Female	267	3.7
Male	6977	96.3
Total*	**7244**	**100**

Data Source: LabCorp.

*Data does not include observations with missing sex (n=1101).

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 16, 2024.

Table C3. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Sex, FY 2021 (October 1, 2020–September 30, 2021)

Sex	Female			Male		
Analyte	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
PFHxS	136	1.20 (1.03-1.40)	21	5784	3.00 (2.94-3.07)	340
PFNA	210	0.31 (0.29-0.33)	2.5	5954	0.41 (0.41-0.42)	8.8
Linear PFOA	214	0.65 (0.54-0.77)	24	6004	1.15 (1.12-1.17)	24
Linear PFOS	214	1.72 (1.53-1.93)	19	5995	3.19 (3.12-3.26)	150

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table C4. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Sex, FY 2022 (October 1, 2021–September 30, 2022)

Sex	Female			Male		
Analyte	Total Valid Tests	Geometric Mean[a]	Maximum Value	Total Valid Tests	Geometric Mean[a]	Maximum Value
PFHxS	230	0.86 (0.78-0.96)	27	7115	2.40 (2.35-2.45)	63
PFNA	267	0.26 (0.25-0.28)	2.1	7172	0.35 (0.35-0.36)	8.2
Linear PFOA	273	0.54 (0.46-0.63)	10	7233	1.01 (0.99-1.03)	23
Linear PFOS	273	1.43 (1.29-1.59)	13	7242	2.76 (2.71-2.81)	63

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table C5. PFAS Laboratory Testing Among Participating DoD Firefighters Using Proprietary Analytical Methodology by Sex, FY 2023 (October 1, 2022–April 30, 2023)

Sex	Female			Male		
Analyte	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
PFHxS	152	0.79 (0.70-0.89)	28	3862	2.13 (2.07-2.20)	65
PFNA	152	0.26 (0.24-0.28)	1.3	3878	0.33 (0.32-0.33)	8.1
Linear PFOA	152	0.53 (0.43-0.66)	13	3879	0.93 (0.90-0.96)	18
Linear PFOS	152	1.29 (1.11-1.50)	12	3877	2.41 (2.35-2.48)	91

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table C6. PFAS Laboratory Testing Among Participating DoD Firefighters Using CDC Analytical Methodology by Sex, FY 2023 (May 1, 2023–September 30, 2023)

Sex	Female			Male		
Analyte	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
PFHxS	139	0.61 (0.54-0.69)	31	2803	1.73 (1.72-1.85)	43
PFNA	139	0.22 (0.20-0.24)	0.77	2803	0.30 (0.30-0.31)	5.8
Linear PFOA	139	0.65 (0.59-0.72)	11	2801	0.95 (0.93-0.98)	17
Linear PFOS	139	1.38 (1.20-1.58)	8.4	2803	3.50 (3.38-3.62)	54

Data Source: LabCorp.

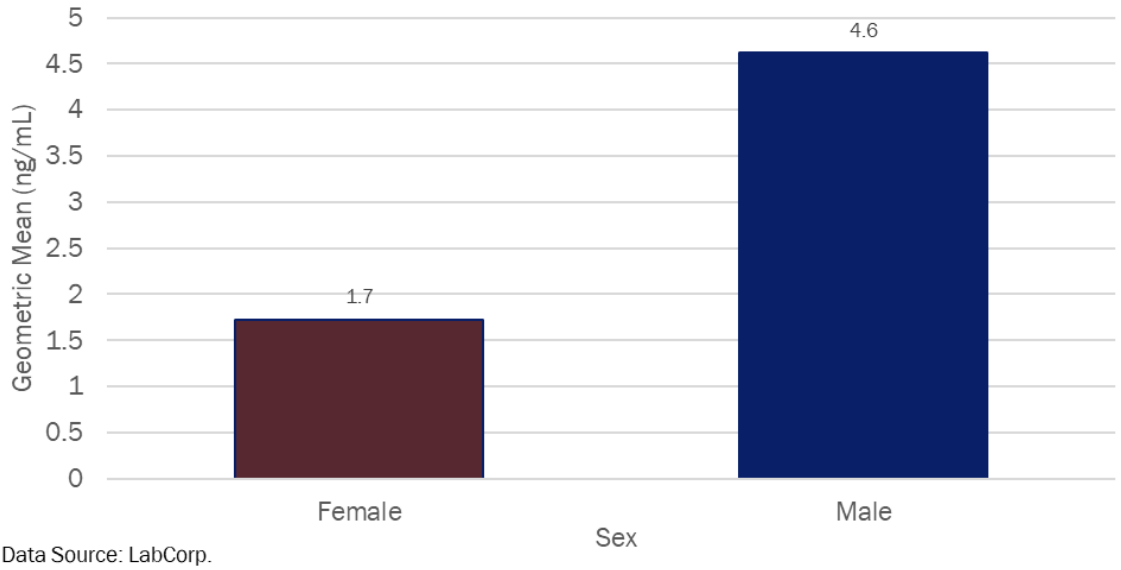
[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

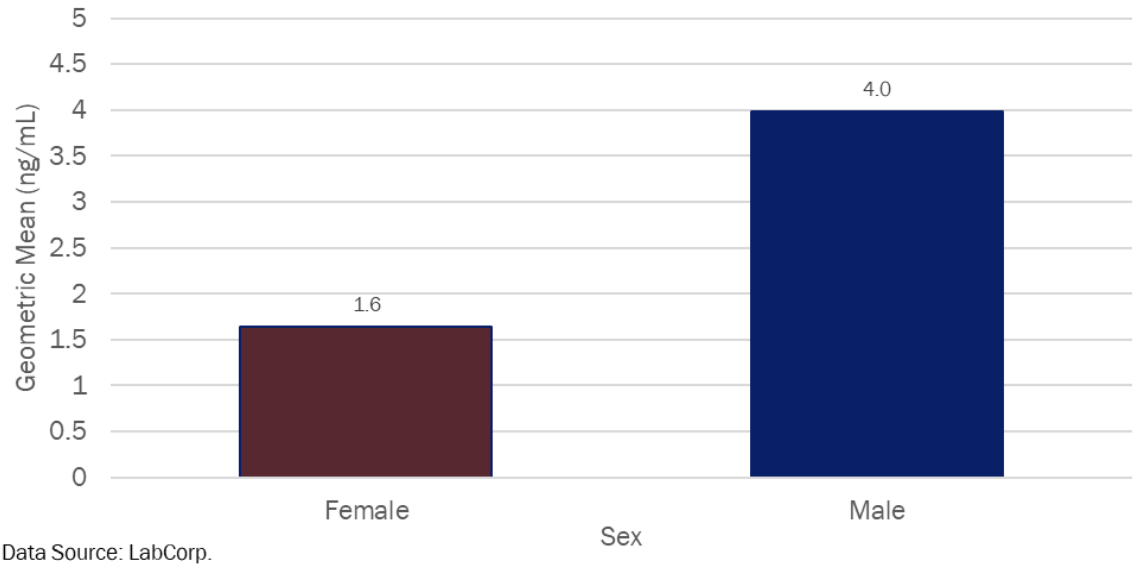
Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Figure C1. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Sex, FY 2021



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Figure C2. Geometric Mean of Total Blood PFAS Level Using Proprietary Analytical Methodology, by Sex, FY 2022



Data Source: LabCorp.
Total Blood PFAS Level was calculated as the sum of PFHxS, PFNA and linear isomer of PFOA values.
Data prepared by the EpiData Center (EDC), Defense Centers for Public Health- Portsmouth (DCPH-P) on September 23, 2024.

Appendix D: PFAS Age and Sex Distribution FY 2021–FY 2023

FY 2021

Table D1. PFAS Laboratory Testing Among Participating Female DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2021 (October 1, 2020–September 30, 2021)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	2	0.86 (0.14-5.39)	1	6	0.27 (0.16-0.44)	0.61
20-24	15	1.19 (0.83-1.70)	4.8	35	0.28 (0.24-0.32)	0.55
25-29	29	1.09 (0.81-1.46)	6.2	46	0.28 (0.24-0.33)	2.5
30-34	23	1.10 (0.66-1.84)	7.5	34	0.30 (0.25-0.37)	0.96
35-39	27	1.31 (0.90-1.90)	18	37	0.34 (0.29-0.40)	1
40-44	20	1.14 (0.79-1.64)	4.6	26	0.30 (0.24-0.38)	1.2
≥ 45	20	1.50 (0.91-2.48)	21	26	0.41 (0.31-0.54)	0.94
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	6	0.94 (0.75-1.19)	1.3	6	1.26 (0.59-2.72)	4.3
20-24	35	0.57 (0.39-0.82)	1.9	35	1.44 (1.19-1.74)	8.1
25-29	48	0.48 (0.31-0.74)	24	48	1.58 (1.25-2.00)	19
30-34	35	0.81 (0.60-1.11)	3.8	35	1.69 (1.12-2.56)	11
35-39	37	0.73 (0.48-1.12)	3.7	37	2.14 (1.78-2.59)	8
40-44	27	0.58 (0.33-1.01)	2.6	27	1.69 (1.14-2.50)	7.5
≥ 45	26	0.84 (0.47-1.49)	4	26	2.08 (1.39-3.12)	4.9

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table D2. PFAS Laboratory Testing Among Participating Male DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2021 (October 1, 2020–September 30, 2021)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	60	0.95 (0.82-1.09)	4.2	81	0.32 (0.28-0.36)	4.8
20-24	640	1.52 (1.44-1.60)	26	706	0.33 (0.32-0.34)	2.4
25-29	727	2.20 (2.09-2.32)	22	750	0.36 (0.35-0.37)	1.7
30-34	833	2.90 (2.76-3.06)	30	858	0.39 (0.38-0.41)	3.9
35-39	1104	3.42 (3.28-3.57)	33	1115	0.43 (0.42-0.44)	7.5
40-44	989	3.55 (3.38-3.72)	340	999	0.44 (0.43-0.46)	8.8
≥ 45	1431	4.11 (3.95-4.29)	48	1445	0.47 (0.46-0.49)	8.6
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	82	0.71 (0.58-0.87)	2.5	82	1.26 (1.08-1.47)	3.4
20-24	718	0.90 (0.85-0.94)	4	718	2.16 (2.06-2.26)	35
25-29	762	0.98 (0.92-1.03)	5.2	760	2.98 (2.84-3.13)	26
30-34	863	1.15 (1.09-1.21)	7.8	863	3.29 (3.11-3.49)	53
35-39	1123	1.21 (1.15-1.27)	12	1121	3.60 (3.44-3.76)	44
40-44	1006	1.27 (1.20-1.33)	21	1004	3.55 (3.37-3.74)	65
≥ 45	1450	1.31 (1.25-1.37)	24	1447	3.51 (3.36-3.67)	150

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

FY 2022

Table D3. PFAS Laboratory Testing Among Participating Female DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2022 (October 1, 2021–September 30, 2022)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	10	0.51 (0.35-0.73)	1.6	11	0.18 (0.15-0.22)	0.3
20-24	42	0.63 (0.51-0.77)	4.1	50	0.20 (0.18-0.23)	0.55
25-29	44	0.71 (0.58-0.87)	10	54	0.24 (0.22-0.27)	0.51
30-34	36	0.88 (0.67-1.15)	8.6	42	0.25 (0.21-0.29)	0.82
35-39	42	1.06 (0.83-1.36)	12	50	0.33 (0.29-0.38)	0.95
40-44	27	0.99 (0.70-1.40)	27	29	0.28 (0.23-0.34)	1.7
≥ 45	29	1.46 (1.02-2.07)	15	31	0.39 (0.32-0.49)	2.1
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	12	0.51 (0.29-0.87)	0.85	12	0.81 (0.41-1.59)	2.3
20-24	53	0.39 (0.28-0.56)	1.3	53	1.08 (0.86-1.35)	4.7
25-29	54	0.36 (0.24-0.54)	2.2	54	1.24 (0.98-1.56)	5.7
30-34	42	0.62 (0.44-0.88)	3.1	42	1.41 (1.10-1.83)	7.4
35-39	51	0.64 (0.46-0.91)	2.6	51	1.96 (1.64-2.33)	9.4
40-44	29	0.70(0.45-1.09)	7	29	1.58 (1.10-2.27)	7.7
≥ 45	32	0.87 (0.54-1.42)	10	32	2.05 (1.43-2.95)	13

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table D4. PFAS Laboratory Testing Among Participating Male DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2022 (October 1, 2021–September 30, 2022)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	101	0.75 (0.68-0.82)	3.5	107	0.27 (0.25-0.29)	0.67
20-24	915	1.11 (1.07-1.16)	45	946	0.29 (0.28-0.30)	2.5
25-29	953	1.78 (1.69-1.86)	19	956	0.31 (0.30-0.32)	1.4
30-34	1074	2.26 (2.15-2.38)	38	1083	0.34 (0.33-0.35)	3.4
35-39	1281	2.85 (2.73-2.98)	40	1290	0.37 (0.36-0.38)	6.1
40-44	1183	3.04 (2.90-3.19)	57	1184	0.37 (0.36-0.38)	8.2
≥ 45	1608	3.64 (3.49-3.80)	63	1606	0.40 (0.39-0.42)	8
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	109	0.54 (0.44-0.68)	2.1	109	1.29 (1.19-1.39)	4.3
20-24	963	0.74 (0.70-0.79)	6.2	963	1.82 (1.76-1.88)	35
25-29	965	0.90 (0.85-0.95)	5.7	966	2.49 (2.38-2.60)	63
30-34	1091	0.97 (0.91-1.02)	8	1092	2.83 (2.70-2.97)	49
35-39	1299	1.13 (1.07-1.18)	11	1301	3.17 (3.04-3.31)	49
40-44	1190	1.11 (1.05-1.17)	12	1192	2.99 (2.85-3.14)	34
≥ 45	1616	1.19 (1.14-1.25)	23	1619	3.29 (3.16-3.42)	47

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

FY 2023

Proprietary Analytical Methodology

Table D5. PFAS Laboratory Testing Among Participating Female DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2023 (October 1, 2022–April 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	7	0.77 (0.37-1.59)	3.1	7	0.29 (0.17-0.48)	0.73
20-24	27	0.63 (0.50-0.80)	2.2	27	0.21 (0.18-0.24)	0.45
25-29	34	0.69 (0.57-0.83)	1.8	34	0.24 (0.21-0.28)	0.74
30-34	20	0.82 (0.48-1.42)	28	20	0.25 (0.20-0.32)	0.82
35-39	28	0.85 (0.65-1.11)	5.9	28	0.27 (0.23-0.33)	0.7
40-44	13	0.98 (0.63-1.53)	3.8	13	0.29 (0.21-0.40)	0.7
≥ 45	23	1.00 (0.74-1.37)	3	23	0.33 (0.26-0.43)	1.3
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	7	0.78 (0.65-0.94)	1	7	1.14 (0.72-1.79)	2.6
20-24	27	0.38 (0.21-0.68)	6.1	27	1.03 (0.76-1.39)	3.2
25-29	34	0.62 (0.44-0.86)	1.5	34	1.29 (0.98-1.70)	6.2
30-34	20	0.49 (0.24-0.99)	13	20	1.00 (0.55-1.83)	5.8
35-39	28	0.52 (0.31-0.86)	2.1	28	1.67 (1.38-2.02)	5.7
40-44	13	0.48(0.19-1.20)	1.9	13	1.40 (0.64-3.10)	6.7
≥ 45	23	0.68 (0.36-1.28)	3.7	23	1.52 (0.93-2.47)	12

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table D6. PFAS Laboratory Testing Among Participating Male DoD Firefighters Using Proprietary Analytical Methodology by Age Group, FY 2023 (October 1, 2022–April 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	61	0.71 (0.62-0.81)	3.3	61	0.24 (0.21-0.26)	0.63
20-24	549	1.04 (0.98-1.09)	11	549	0.27 (0.26-0.28)	0.89
25-29	523	1.56 (1.46-1.66)	16	528	0.29 (0.28-0.30)	1.3
30-34	574	2.14 (2.01-2.29)	36	577	0.32 (0.31-0.33)	3.3
35-39	633	2.45 (2.29-2.63)	27	637	0.35 (0.33-0.36)	4.4
40-44	628	2.71 (2.51-2.91)	46	630	0.34 (0.33-0.36)	5.6
≥ 45	894	3.29 (3.11-3.48)	65	896	0.38 (0.36-0.40)	8.1
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	61	0.60 (0.47-0.78)	3	61	1.13 (0.96-1.33)	6.9
20-24	549	0.75 (0.70-0.80)	3.7	549	1.61 (1.53-1.69)	30
25-29	528	0.77 (0.70-0.83)	3.4	528	2.07 (1.95-2.21)	27
30-34	578	0.95 (0.88-1.02)	6.4	578	2.54 (2.39-2.70)	17
35-39	637	0.97 (0.90-1.05)	5.1	637	2.73 (2.55-2.91)	36
40-44	630	1.03 (0.96-1.11)	10	629	2.77 (2.58-2.98)	22
≥ 45	896	1.08 (1.02-1.15)	18	895	2.86 (2.71-3.02)	91

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are not directly comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

CDC Analytical Methodology

Table D7. PFAS Laboratory Testing Among Participating Female DoD Firefighters Using CDC Analytical Methodology by Age Group, FY 2023 (May 1, 2023–September 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	7	0.40 (0.24-067)	0.81	7	0.17 (0.11-0.25)	0.31
20-24	28	0.48 (0.39-0.60)	2.2	28	0.19 (0.16-0.21)	0.36
25-29	26	0.52 (0.40-0.68)	2.5	26	0.18 (0.15-0.21)	0.38
30-34	26	0.64 (0.42-096)	31	26	0.22 (0.17-0.27)	0.63
35-39	25	0.69 (0.53-0.90)	2.4	25	0.27 (0.22-0.33)	0.74
40-44	13	0.92 (0.62-1.37)	3.5	13	0.25 (0.17-0.36)	0.64
≥ 45	14	0.83 (0.52-1.33)	5.5	14	0.38 (0.28-0.53)	0.77
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	7	0.52 (0.37-0.74)	0.93	7	0.94 (0.67-1.32)	1.4
20-24	28	0.56 (0.48-0.65)	1.3	28	1.08 (0.88-1.32)	6.8
25-29	26	0.49 (0.39-0.62)	1.3	26	1.09 (0.79-1.50)	7.3
30-34	26	0.64 (0.48-0.85)	11	26	1.36 (0.95-1.96)	7
35-39	25	0.79 (0.60-0.1.04)	5.2	25	1.67 (1.19-2.34)	7.9
40-44	13	0.68(0.51-0.91)	1.7	13	1.84 (0.95-3.56)	6.8
≥ 45	14	1.10 (0.84-1.43)	2.2	14	2.34 (1.57-3.48)	8.4

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.

Table D8. PFAS Laboratory Testing Among Participating Male DoD Firefighters Using CDC Analytical Methodology by Age Group, FY 2023 (May 1, 2023–September 30, 2023)

Analyte	PFHxS			PFNA		
Age Group (Years)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)	Total Valid Tests	Geometric Mean (ng/mL)[a]	Maximum Value (ng/mL)
<20	66	0.71 (0.63-0.78)	3.4	66	0.26 (0.22-0.30)	3.1
20-24	444	0.90 (0.85-0.95)	7.8	444	0.25 (0.24-0.26)	1.4
25-29	360	1.44 (1.33-1.56)	19	360	0.28 (0.26-0.29)	1.9
30-34	398	1.69 (1.56-1.84)	17	398	0.29 (0.27-0.30)	3.6
35-39	457	2.06 (1.90-2.24)	20	457	0.31 (0.30-0.33)	1.4
40-44	436	2.40 (2.22-2.59)	34	436	0.33 (0.31-0.34)	3.2
≥ 45	642	2.70 (2.50-2.91)	43	642	0.36 (0.35-0.38)	5.8
Analyte	**Linear PFOA**			**Linear PFOS**		
Age Group (Years)	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**	**Total Valid Tests**	**Geometric Mean (ng/mL)[a]**	**Maximum Value (ng/mL)**
<20	66	0.74 (0.65-0.83)	3.6	66	1.49 (1.31-1.69)	12
20-24	444	0.77 (0.74-0.80)	4.4	444	1.72 (1.62-1.81)	18
25-29	360	0.88 (0.84-0.92)	4.4	360	2.61 (2.42-2.82)	15
30-34	398	0.89 (0.84-0.94)	16	398	3.17 (2.91-3.45)	23
35-39	457	1.00 (0.95-1.06)	8.8	457	3.96 (3.66-4.29)	23
40-44	434	1.07 (1.01-1.13)	7.4	436	4.89 (4.51-5.30)	37
≥ 45	642	1.11 (1.05-1.17)	17	642	5.73 (5.32-6.17)	54

Data Source: LabCorp.

[a] 95% Confidence Limits were calculated for the geometric mean.

Includes service members (SMs) and civilian firefighters.

Values are comparable to CDC-NHANES Per- and Polyfluoroalkyl reporting.

Prepared by the EpiData Center, Defense Centers for Public Health - Portsmouth (DCPH-P) on September 23, 2024.