PFAS in the Line of Duty: Results of a Biomonitoring Study of Firefighters and Accelerant Detection Canines

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High Exposure Occupations

- Firefighter and first responder exposure
  - Aqueous Film Forming Foam (AFFF)
    - Training exercises
    - Site cleanup
    - Contaminated work environments
  - Protective turn out gear
    - Uniform
    - Jacket
    - Pants
    - Boots
    - Respirator
    - Helmet

Photo reference - https://www.cdnfirefighter.com/pfas-lets-talk-about-it/

Need for Biomonitoring

- Focused biomonitoring studies provide valuable information on exposure levels

- Determination of occupational PFAS exposure

- Effectiveness of safety measures

- Identify and enable interventions

- Results will help guide future health and safety strategies for those most at risk

Willow
Accelerant Detection Canine, Calgary Fire Department

Whole Blood, Serum and Plasma Definitions

- Whole blood – contains all components of blood, including red and white blood cells, platelets and plasma.

- Serum – liquid part of the blood that remains after coagulation, devoid of blood cells and clotting factors.

- Plasma – the liquid component of the blood contains water, salts, enzymes, antibodies and other proteins.

All three of the above can be analyzed by LC-MSMS.

Whole Blood, Serum, and Plasma - Comparison

- Whole blood –
  - Advantage: Represents the total body burden of PFAS since it includes all blood components
  - Challenge: Complex matrix which requires extensive sample preparation and cleanup.
- Plasma –
  - Advantage: Contains proteins and other components that can bind PFAS, providing comprehensive view of PFAS distribution in blood.
  - Challenges: May require additional steps to separate plasma from blood cells adding an additional level of complexity to sample preparation.

Whole Blood, Serum, and Plasma - Comparison

- Serum –
    - Advantage: Widely used in PFAS biomonitoring studies due to its relatively simpler matrix compared to whole blood.
    - Reflects the bioavailable fraction of PFAS that circulates in the body providing important information about exposure levels.
    - There are many established methods existing for PFAS analysis in Serum.

- After reviewing the advantages and challenges associated with these three matrices we decided to proceed with serum.

NHANES Method

- Used as basis for our PFAS in serum method

  - Isotopically labeled standards

  - LCMSMS quantification

- Analysis of the 40 compounds in US EPA 1633

- Determination of human exposure through complex multistage probability sampling design

- Data collection by interviews and examinations

Biomonitoring to date

- Health Canada reported there are no available Canadian studies on biomonitoring of PFAS levels in firefighters noted as of March 2025

- 13 international studies have concentrations available for PFOS and PFOA in firefighters

- Canadian Health Measures Survey (CHMS) measures only 9 PFAS compounds

Biomonitoring Compounds of Interest

| Compound Name	Abbreviation
Perfluorooctanesulfonic acid	PFOS
Perfluorooctanoic acid	PFOA
Perfluorohexanesulfonic acid	PFHxS
Perfluorononanoic acid	*PFNA*
Perfluorodecanoic acid	*PFDA*

PFOS   PFOA   PFHxS
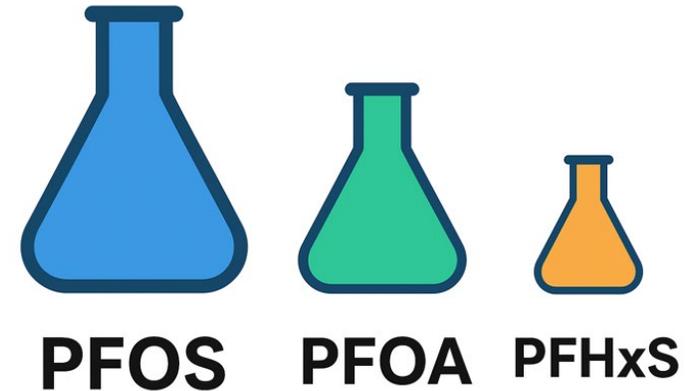
With regulatory guidelines in place the levels of these compounds has been found to be decreasing.

The above parameters make up 85% of results observed, remaining are PFDA, PFUnA, 4:2-FTS, HFPO-DA, PFPeA, PFTrDA, PFBS, NEtFOSE.

Biomonitoring to date

PFAS Serum Concentrations - 13 International studies (10 in USA)
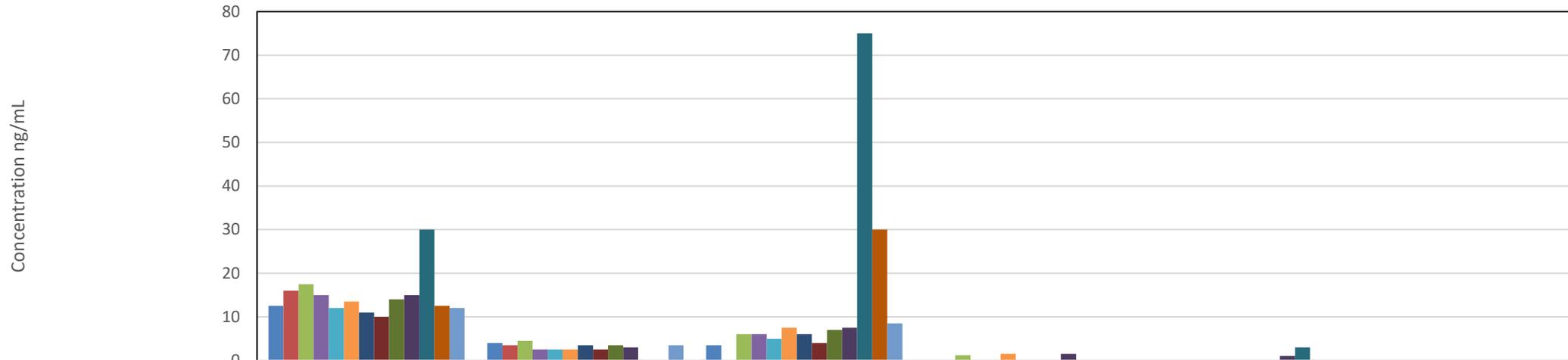
	PFOS	PFOA	PFHxS	PFNA	PFHpS	Other PFAS
Jin 2011 (US)	12.5	4	3.5	0	0	0
Shaw 2013 (US)	16	3.5	0	0	0	0
Dobraca 2015 (US)	17.5	4.5	6	1.2	0	0
Khalil 2020 (US)	15	2.5	6	0	0	0
Leary 2020 (US)	12	2.5	5	0	0	0
Trowbridge 2020 (US)	13.5	2.5	7.5	1.5	0	0
Goodrich 2021a (US)	11	3.5	6	0	0	0
Graber 2021 (US)	10	2.5	4	0	0	0
Barton 2022 (US)	14	3.5	7	0	0	0
Burgess 2022 (US, 5 datasets)	15	3	7.5	1.5	1	0
Rotander 2015 (Australia)	30	0	75	0	3	0
Nilsson 2022a (Australia)	12.5	0	30	0	0	0
Laitinen 2014 (Finland)	12	3.5	8.5	0	0	0

Why?

Concern:

Firefighters wanted to determine their PFAS in serum levels due to higher exposure

Objective:

Quantify and compare PFAS in serum concentrations in:

- Firefighters
- Accelerant detection canines
- Leisure (non-working) canines
- Laboratory personnel

Titus
Accelerant Detection Canine, Calgary Fire Department

AGAT Biomonitoring study

✓ 40 compounds

✓ Isotopically labeled standards

✓ LCMSMS

✓ Fully accredited method tailored for PFAS in serum biomonitoring applications

Participants were selected to ensure variation across the following areas:
- Age
- Gender at birth
- Ethnicity
- Specialty Areas (Firefighter, Hazmat, Technical Rescue, Office, etc)
- Length of service

Questionnaire

- To supplement the data and enhance interpretation of results a questionnaire was administered to participants.

- Examples of questions included:
    - Age range
    - Gender assigned at birth
    - Ethnic Origin
    - Length of service
    - Frequency of consumption of packaged or processed foods
    - Frequency of non-stick cookware use

- Responses will assist in understanding potential factors contributing to PFAS exposure

Participants

- 50 Firefighters
- 2 accelerant detection canines
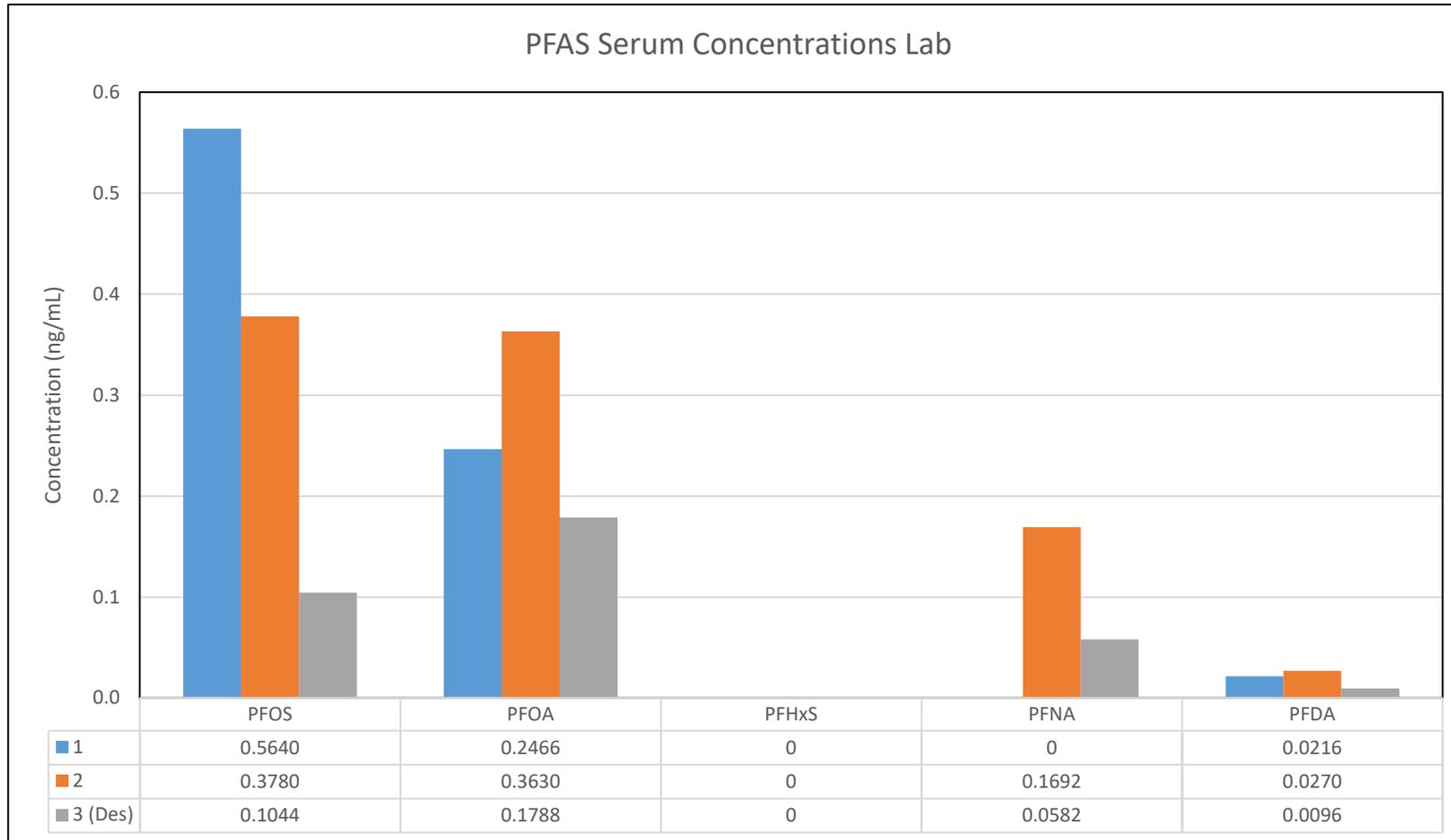- 4 non working canine participants
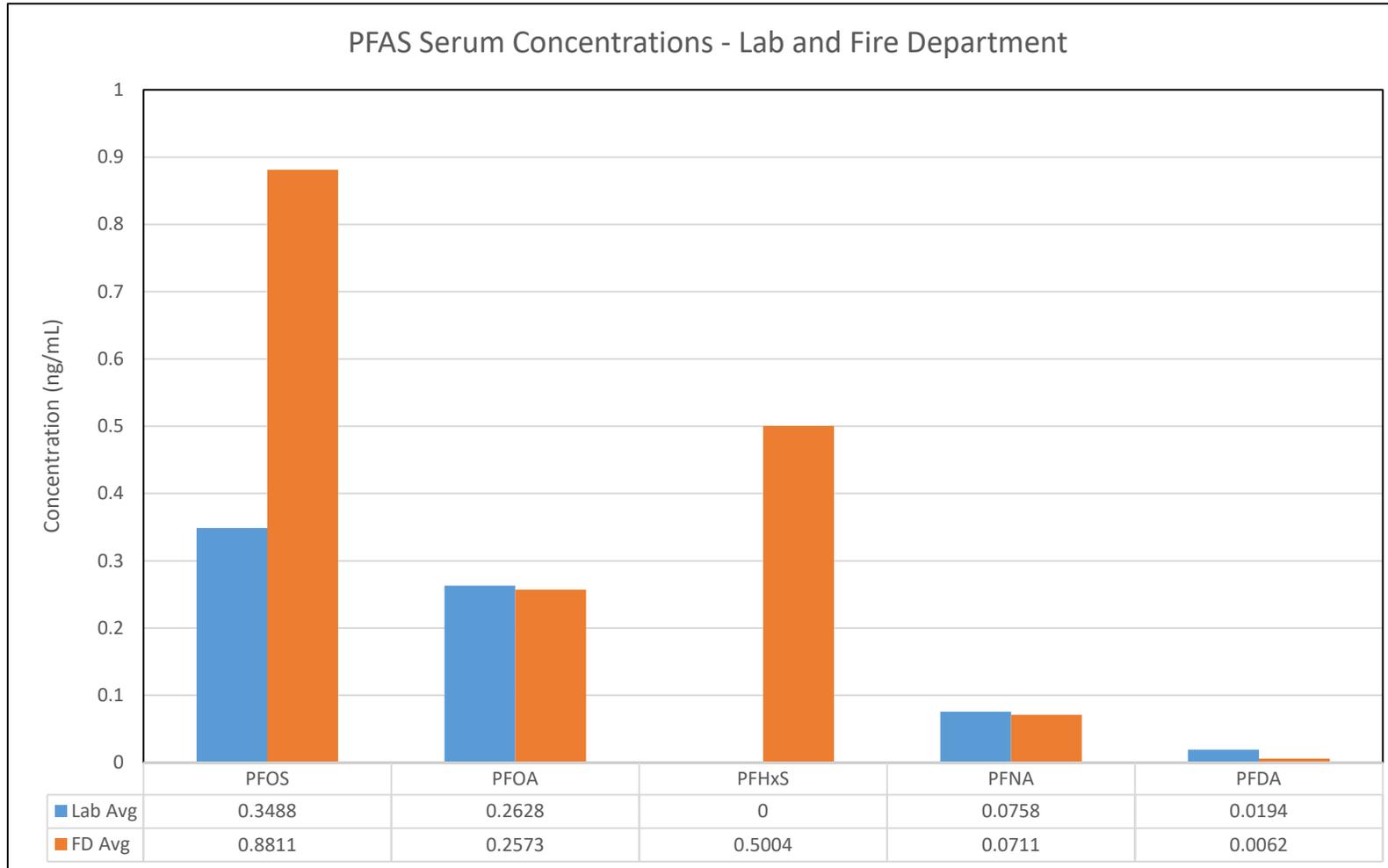- 3 AGAT staff

Results – Lab participants

Parameter	1 Final Conc. (ng/mL)	2 Final Conc. (ng/mL)	3 (Des) Final Conc. (ng/mL)
01. PFBA	<0.1	<0.1	<0.1
02. PFPeA	0.1554	0.0750	0.1236
03. PFHxA	<0.1	<0.1	<0.1
04. PFHpA	0.0042	<0.1	<0.1
05.PFOA	**0.2466**	**0.3630**	**0.1788**
06. PFNA	<0.1	0.1692	0.0582
07. PFDA	0.0216	0.0270	0.0096
08. PFUdA	<0.1	0.1320	0.0780
09. PFDoA	<0.1	<0.1	<0.1
10. PFTrDA	<0.1	0.0168	<0.1
11. PFTeDA	<0.1	<0.1	<0.1
12. PFBS	0.0144	<0.1	0.0246
13. PFPeS	<0.1	<0.1	<0.1
14. PFHxS	**<0.1**	**<0.1**	**<0.1**
15. PFHpS	<0.1	<0.1	<0.1
16. PFOS	**0.5640**	**0.3780**	**0.1044**
17. PFNS	<0.1	<0.1	<0.1
18. PFDS	<0.1	<0.1	<0.1
19. PFDoS	<0.1	<0.1	<0.1
20. 4:2-FTS	0.0150	0.0156	0.0264

Parameter	1 Final Conc. (ng/mL)	2 Final Conc. (ng/mL)	3 (Des) Final Conc. (ng/mL)
21. 6:2-FTS	<0.5	<0.5	<0.5
22. 8:2-FTS	<0.5	<0.5	<0.5
23. PFOSA	<0.1	<0.1	<0.1
24. NMeFOSA	<0.1	<0.1	<0.1
25. NEtFOSA	<0.1	<0.1	<0.1
26. N-MeFOSAA	<0.1	<0.1	<0.1
27. N-EtFOSAA	<0.1	<0.1	<0.1
28. NMeFOSE	<1	<1	<1
29. NEtFOSE	<1	<1	<1
30. HFPO-DA	<0.1	<0.1	<0.1
31. ADONA	<0.1	<0.1	<0.1
32. 9Cl-PF3ONS	<0.1	<0.1	<0.1
33. 11Cl-PF3OUdS	<0.1	<0.1	<0.1
34. 3:3 FTCA	<1	<1	<1
35. 5:3 FTCA	<1	<1	<1
36. 7:3 FTCA	<1	<1	<1
37. PFEESA	<0.1	<0.1	<0.1
38. PFMPA	<0.1	<0.1	<0.1
39. PFMBA	<0.1	<0.1	<0.1
40. NFDHA	<1	<1	<1

Results – Lab participants

PFAS Serum Concentrations Lab

	PFOS	PFOA	PFHxS	PFNA	PFDA
■ 1	0.5640	0.2466	0	0	0.0216
■ 2	0.3780	0.3630	0	0.1692	0.0270
■ 3 (Des)	0.1044	0.1788	0	0.0582	0.0096

Results – Lab and Fire Department

PFAS Serum Concentrations - Lab and Fire Department

Concentration (ng/mL)

	PFOS	PFOA	PFHxS	PFNA	PFDA
■ Lab Avg	0.3488	0.2628	0	0.0758	0.0194
■ FD Avg	0.8811	0.2573	0.5004	0.0711	0.0062

Possible Exposure Sources

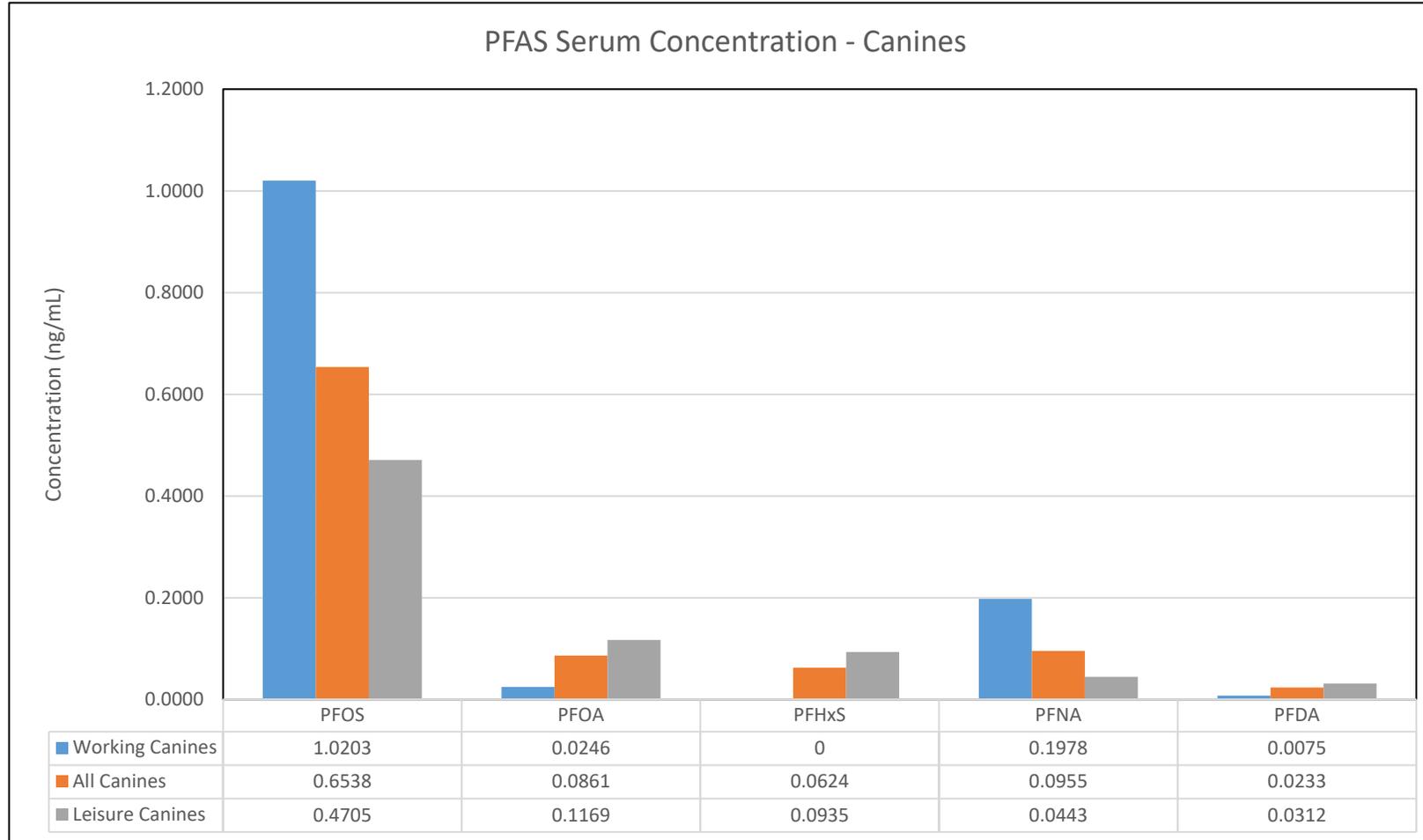| Compound	Main Uses (historical/industrial)	Current Exposure Sources
PFOS (Perfluorooctane sulfonic acid)	Firefighting foams (AFFF), stain-resistant textiles, carpets, paper/food packaging, industrial surfactant	Contaminated drinking water, food, dust, legacy contamination near airports/military bases
PFOA (Perfluorooctanoic acid)	Non-stick cookware (Teflon® production), stain/water-resistant coatings, food packaging, firefighting foams, fluoropolymer processing aid	Contaminated drinking water, food, dust, manufacturing sites
PFHxS (Perfluorohexane sulfonic acid)	Firefighting foams (AFFF), textile and carpet treatments, paper/packaging, electroplating	Drinking water (esp. near AFFF sites), dust, food
PFNA (Perfluorononanoic acid)	Fluoropolymer processing aid, textiles/leather treatments, food packaging, electronics	Drinking water, fish, food, indoor dust
PFDA (Perfluorodecanoic acid)	Fluoropolymer/plastic processing aid, surface treatments, food packaging	Water, sediments, fish/wildlife, food chain

Canine Participants

- Serum donations obtained during routine checkups from Axel, Rex, Mateo and Larry allowed us to obtain further insight using canine results!
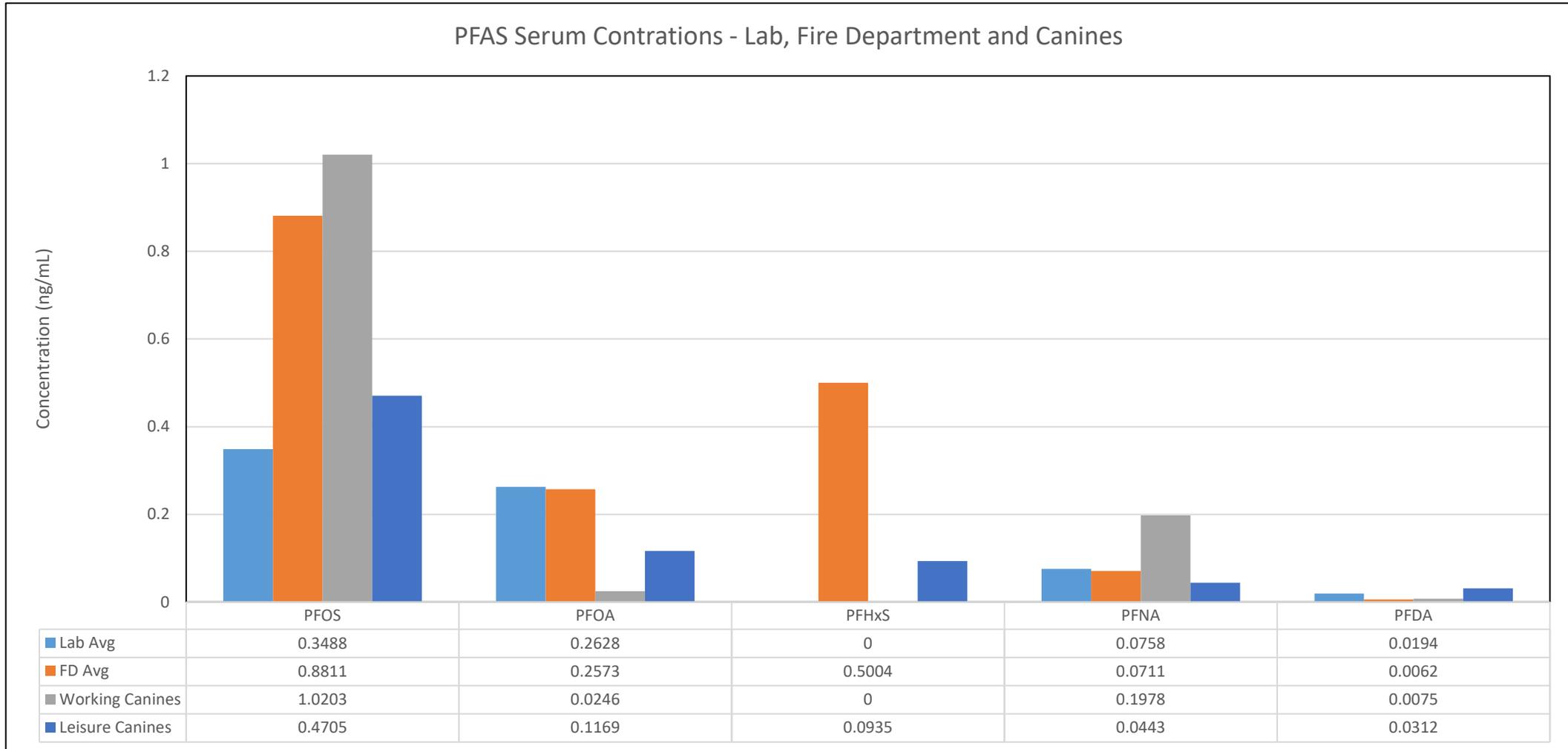

Rex

Mateo

Larry

Axel

Canine Participant Results

	Working Canines		Leisure Canines			
	Willow	Titus	Axel	Mateo	Rex	Larry
Canine Age	7	1	8	8	5	16 months
Canine Breed	Black Lab	Red Lab	Husky	Rottweiler, English Setter, Husky	Pembroke Corgi	Cane Corso
Parameter Abbreviation	Final Conc. ng/mL	Final Conc. ng/mL	Final Conc. ng/mL	Final Conc. ng/mL	Final Conc. ng/mL	Final Conc. ng/mL
PFOS	0.2790	1.7616	0.5650	0.4679	0.4618	0.3875
PFOA	0.0492	<0.1	0.0597	0.2418	0.1661	0.0000
PFHxS	<0.1	<0.1	0.1156	0.1136	0.0932	0.0518
PFNA	<0.1	0.3956	0.0227	0.0567	0.0491	0.0487
PFDA	0.0150	<0.1	0.0314	0.0628	0.0305	<0.1

Canine Participant Results

PFAS Serum Concentration - Canines

	PFOS	PFOA	PFHxS	PFNA	PFDA
Working Canines	1.0203	0.0246	0	0.1978	0.0075
All Canines	0.6538	0.0861	0.0624	0.0955	0.0233
Leisure Canines	0.4705	0.1169	0.0935	0.0443	0.0312

Results – All Study Participants

PFAS Serum Contrations - Lab, Fire Department and Canines

	PFOS	PFOA	PFHxS	PFNA	PFDA
Lab Avg	0.3488	0.2628	0	0.0758	0.0194
FD Avg	0.8811	0.2573	0.5004	0.0711	0.0062
Working Canines	1.0203	0.0246	0	0.1978	0.0075
Leisure Canines	0.4705	0.1169	0.0935	0.0443	0.0312

Results – AGAT Study & International Study Comparison

PFAS Serum Concentrations - AGAT Study and International Studies

	PFOS	PFOA	PFHxS	PFNA	PFDA
Lab Avg	0.3488	0.2628	0	0.0758	0.0194
FD Avg	0.8811	0.2573	0.5004	0.0711	0.0062
Working Canines	1.0203	0.0246	0	0.1978	0.0075
Leisure Canines	0.4705	0.1169	0.0935	0.0443	0.0312
International Studies	14.7000	2.7000	12.8	0.3000	0.0000
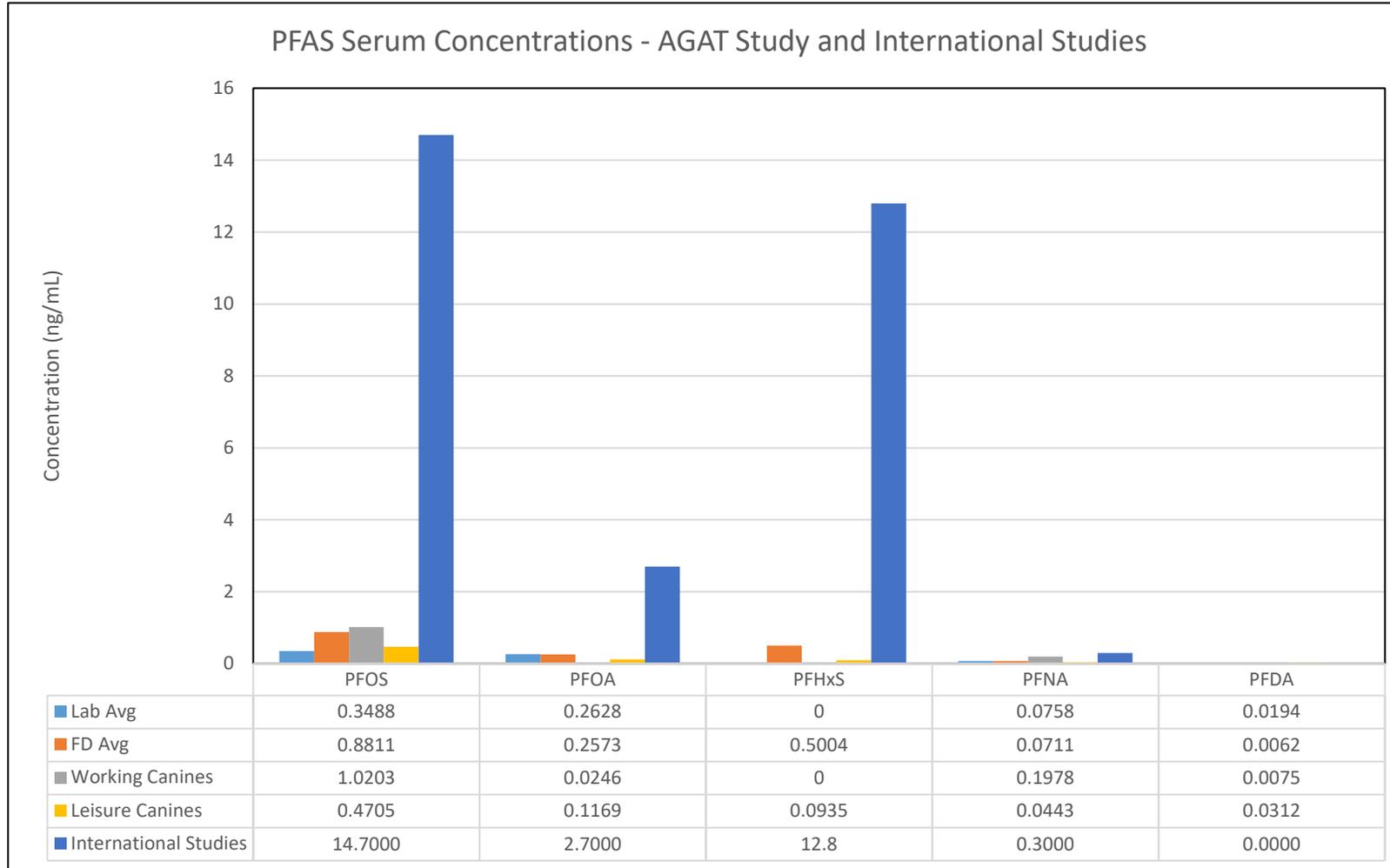
Key Findings

- Firefighters exhibit slightly higher PFOS and PFHxS levels

- Working canines show PFAS profiles similar to firefighters

- Lab personnel show low background PFAS exposure

- PFAS levels in this Canadian study are lower than International datasets

- PFOS remains the dominant compound all groups

Summary and Next Steps

- Data at review stages
- Questionnaire data will provide additional insight into results
- Comparison with existing studies
- Explore potential health and safety recommendations

Keep a look out for the final results!

Thank you!

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