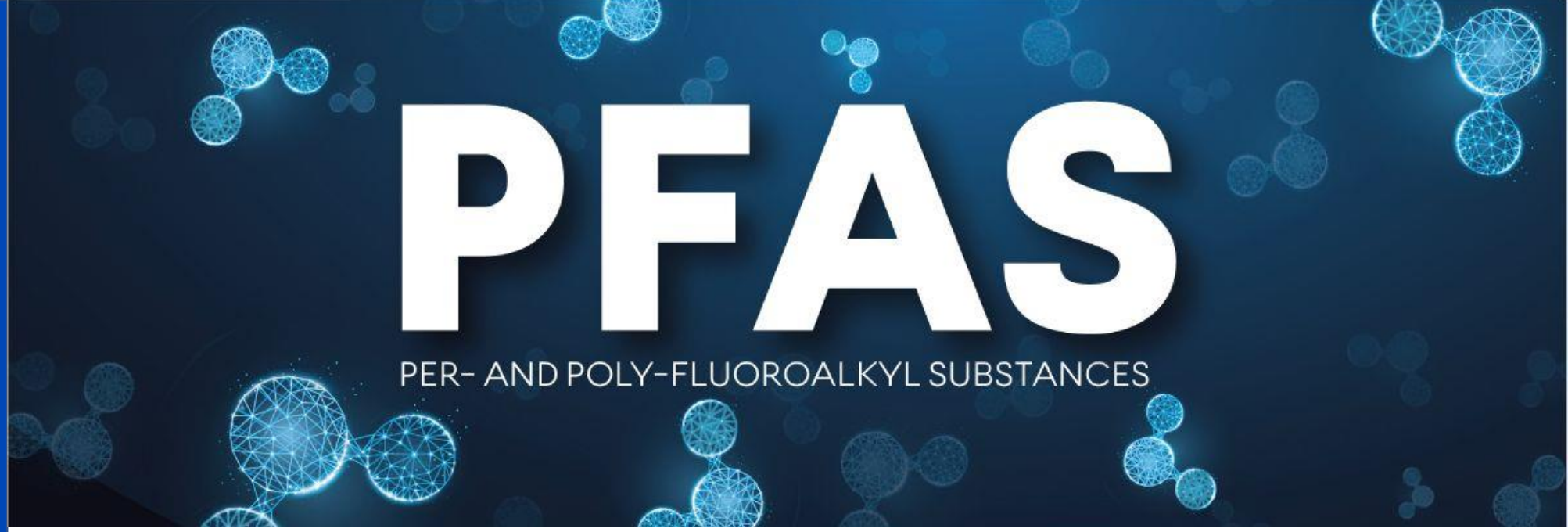

Exposure to PFAS among Canadian Children and its Determinants

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I have no conflict of interest, affiliation, connection or financial interest to declare.

LE JOURNAL DE MONTRÉAL

Des ordres professionnels alertent sur les biosolides en provenance des États-Unis

AGENCE QMI
Jeudi, 8 décembre 2022 06:46
MISE À JOUR Jeudi, 8 décembre 2022 06:46

Trois ordres professionnels recommandent de ne pas utiliser les biosolides municipaux et industriels en provenance des États-Unis, en raison de la présence «inquiétante» de contaminants d'intérêts émergents dommageables pour la santé et l'environnement.

L'Ordre des chimistes du Québec, l'Ordre des agronomes du Québec et l'Ordre des médecins vétérinaires du Québec se disent préoccupés par l'utilisation ces biosolides qui constituent une catégorie de matières résiduelles fertilisantes sous la forme de boues résultant de l'épuration des eaux usées municipales et industrielles.

Les trois ordres professionnels, qui prennent acte de l'intention du gouvernement du Québec de resserrer la réglementation à l'égard de leur utilisation, estiment qu'il y a urgence de légiférer sur les contaminants d'intérêts émergents, dont les substances per et polyfluoroalkylées (PFAS).

Des « contaminants éternels » dans le sang des Canadiens, selon un rapport

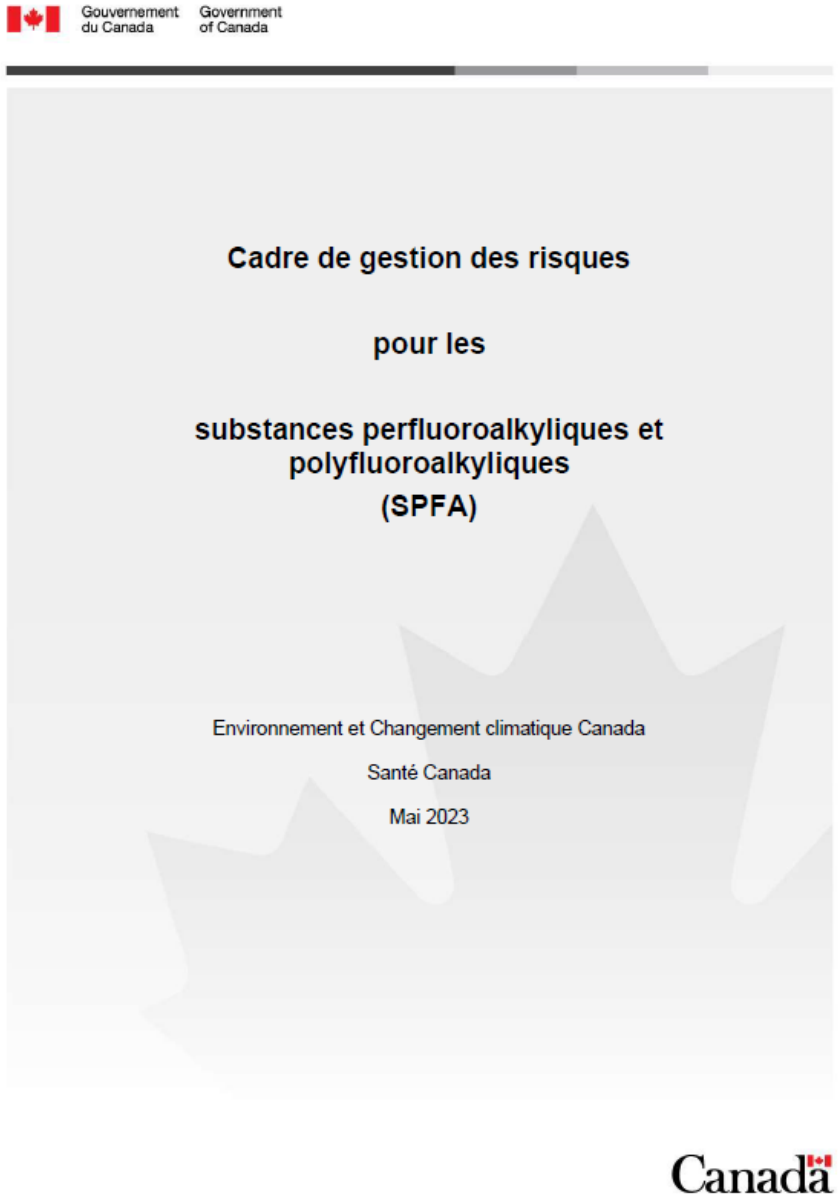
Le rapport du gouvernement indique que les êtres humains sont exposés à «toujours plus de produits chimiques» dans l'air qu'ils respirent, dans la poussière et dans l'eau potable.

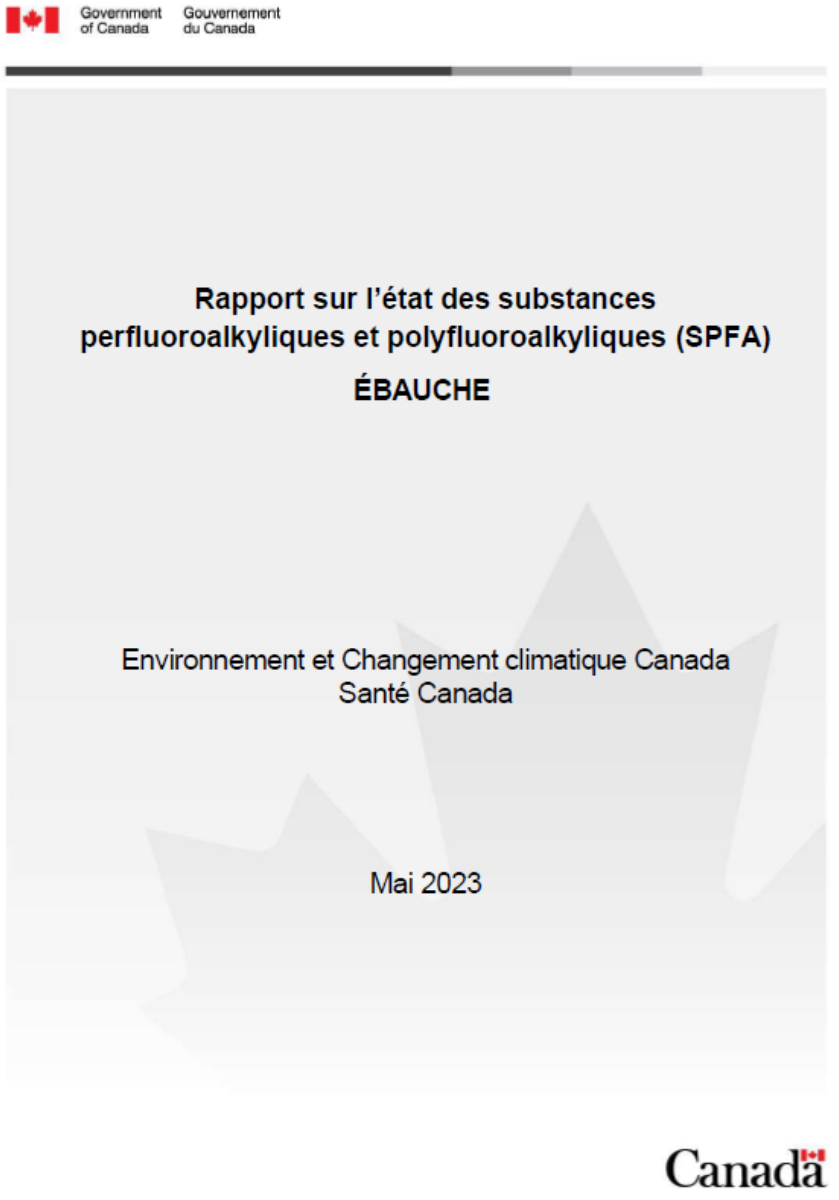
PHOTO : GETTY IMAGES / ASIAVISION

Radio-Canada

Publié le 20 mai 2023

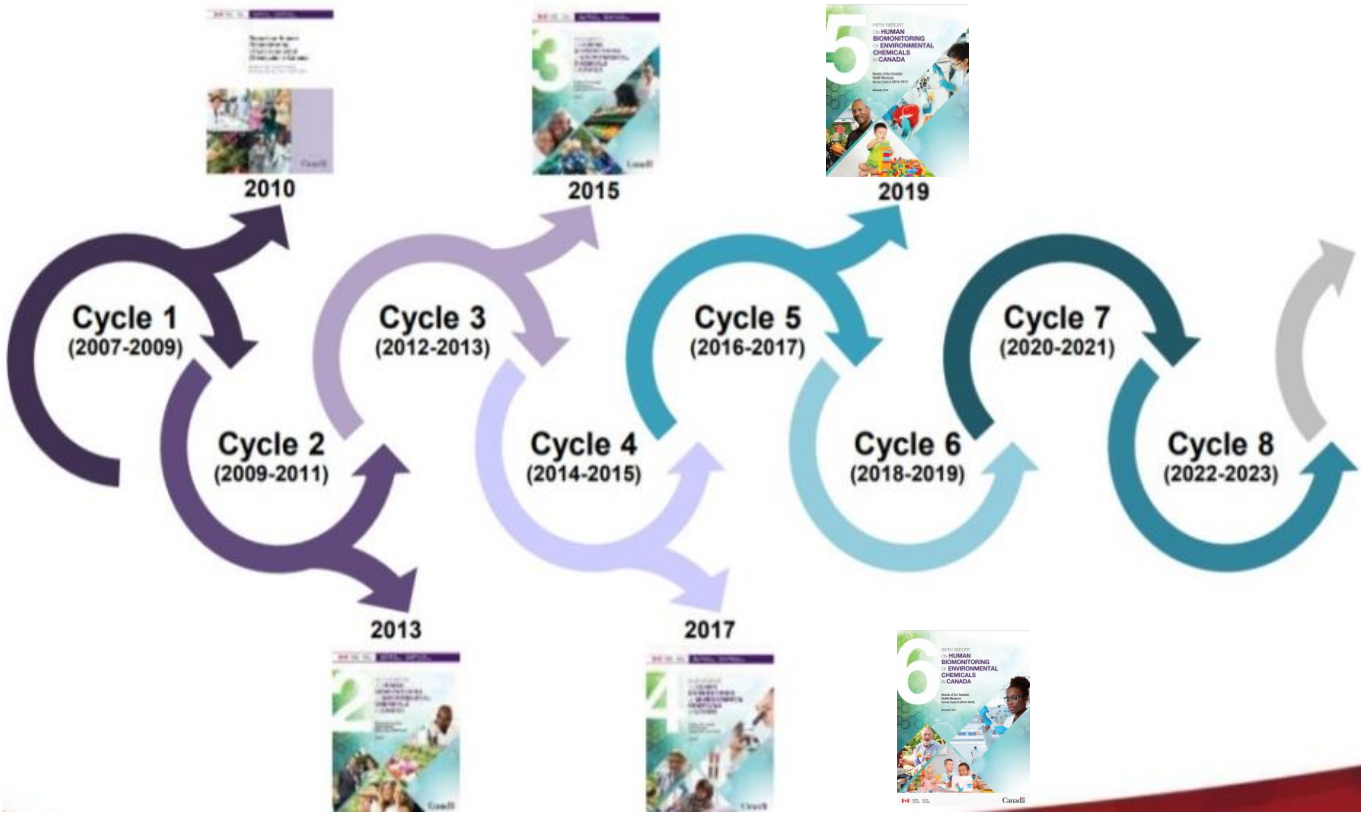
Des « contaminants éternels » toxiques se retrouvent dans le sang des Canadiens, particulièrement au sein des communautés autochtones du Nord, indique un nouveau rapport du gouvernement fédéral.





Background

CHMS – Canadian Health Measure Survey



270 biomarkers of environmental chemicals

>29000 participants
Comprehensive questionnaires

HUMAN BIOMONITORING
Measurement of environmental (parent compound or metabolite) in a biological matrix (blood, urine, etc.…)

Background

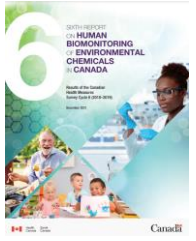
- Cross-sectional survey conducted in 2 years cycles

- Samples between 5,000 and 6,000 Canadians aged 3 to 79 years to produce national estimates per cycle
- Representative of 96-97% of the population

- Six cycles completed (2007-2019)
  - 7th cycle is ongoing

Background

PFAS measurements in CHMS



Chemical	Cycle 1 2007–2009	Cycle 2 2009–2011	Cycle 3 2012–2013	Cycle 4 2014–2015	Cycle 5 2016–2017	Cycle 6 2018–2019
Per- and polyfluoroalkyl substances						
Perfluorobutanoic acid (PFBA)	–	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorobutane sulfonate (PFBS)	–	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorohexanoic acid (PFHxA)	–	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorohexane sulfonate (PFHxS)	HC, 2010	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorooctanoic acid (PFOA)	HC, 2010	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorooctane sulfonate (PFOS)	HC, 2010	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorononanoic acid (PFNA)	–	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluorodecanoic acid (PFDA)	–	HC, 2013	–	–	HC, 2019	HC, 2021
Perfluoroundecanoic acid (PFUnDA)	–	HC, 2013	–	–	HC, 2019	HC, 2021

Objectives

- Main objective: to characterize PFAS exposure in Canadian children

- Specific objectives

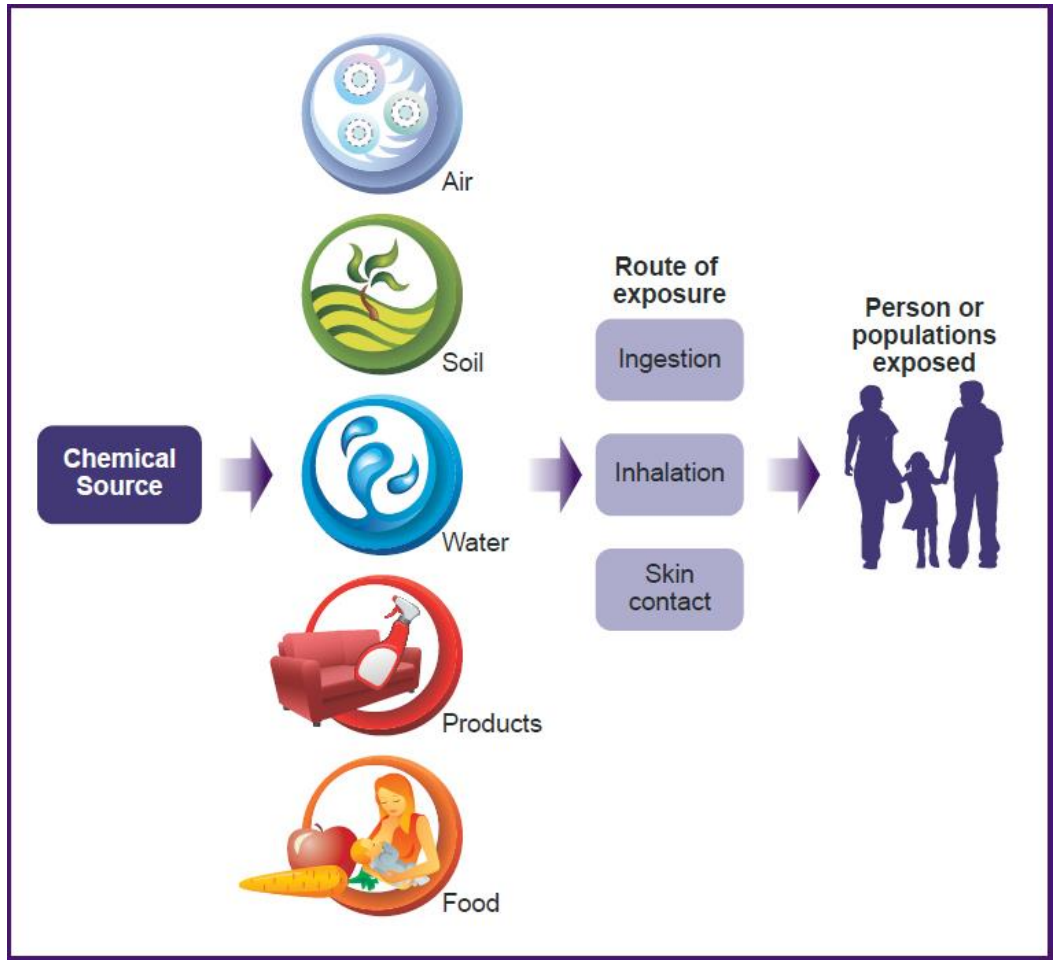
1. Determine the distribution and temporal trends of children's plasma PFAS concentrations in two cycles of CHMS

2. Identify the main determinants of children's plasma PFAS concentrations

Methods

CHMS – Canadian Health Measure Survey

- Study population
  - 3 – 79 y
    - 3-5y
    - 6-11y
    - 12-19y
    - 20-39y
    - 40-59y
    - 60-79y
  - Males and females
  - 16 sampling sites over Canada
  - Approx. 2500 participants/cycle
    - Appox 1250 males and 1250 females per cycle
    - Approx 500 children 3-5y and 500 children 6-11y per cycle
  - Cycle combination to increase # participants and statistical power



Statistical Methods

- Combination of Cycle5 and Cycle6 data together
- Substitution of missing value with LOD/√2
- Variables calculation
  - Income in 3 categories: low, medium, high
  - Education in 2 categories: <university or >university
  - Breastfeeding (Y/N) and duration: <7 months, > 7months
  - BMI in 4 categories: under wieght, normal, overweight, obese
  - Seafood consumption: frequency in the last month
- Log-transformation of data
- Comparisons of means on log-transformed data with adjusted p-value to take into account multiple testing

Study population and representativeness

Study population representative of the Canadian population

- Approx 500 males and females by age group
- Representing more than 3 millions of Canadian children

		Male	Female	Total
3 - <6 yrs	Study	491	490	981
	Population	581 144	549 586	1 130 730
6 - <12 yrs	Study	520	513	1033
	Population	1 192 191	1 143 059	2 335 251
Total	Study	1011	1003	2014
	Population	1 773 336	1 692 645	3 465 981

Frequency of detection of the different compounds

		LOD (µg/L)	LOQ (µg/L)	<LOD (%)	LOD-LOQ (%)	>LOQ (%)	Not stated
PFBA	Perfluoro-n-butyric acid	0.75	0.25	91.93	5.65	1.09	1.33
PFBS	Perfluorobutane sulfonate	0.066	0.22	97.60	0.94	0.04	1.41
PFDA	Perfluorodecanoic acid	0.092	0.31	25.11	60.71	4.10	10.08
PFHA	Perfluorohexanoic acid	0.084	0.18	93.73	3.65	1.45	1.18
PFHS	Perfluorohexane sulfonate	0.063	0.21	0.14	6.38	92.31	1.17
PFNA	Perfluorononanoic acid	0.13	0.43	0.83	55.42	37.72	6.02
PFOA	Perfluorooctanoic acid	0.066	0.22		0.03	98.80	1.17
PFOS	Perfluorooctane sulfonate	0.43	1.4	0.39	41.44	56.99	1.17
PFUD	Perfluoroundecanoic acid	0.12	0.38	85.91	11.32	1.08	1.69

>90% LOD

Concentrations by age and sex

Age groups

- 3-<6y : N=981
- 6-<12y : N=1033

Compound	Age group	GM	GSD
PFOS	3-<6	1.58	0.07
	6-<12	1.62	0.08
PFOA	3-<6	1.39	0.04
	6-<12	1.25	0.05
PFNA	3-<6	0.41	0.02
	6-<12	0.41	0.02
PFHS	3-<6	0.56	0.03
	6-<12	0.56	0.04
PFDA	3-<6	0.13	0.005
	6-<12	0.12	0.006

- No difference between age groups (3-<6 and 6-<12y)
- No difference between males and females in general
- No difference between males and females by age groups

Comparison with Esteban data

Canadian children are slightly less exposed than French children

Distributions des concentrations sériques en PFC (µg L^{-1}) observées chez les enfants âgés de 6 à 17 ans, Esteban (2014-2016)

Biomarqueurs	n	%>LOQ	MG	IC 95 % MG	P10	P25	P50	P75	P90	P95	IC 95 % P95
Carboxylates d'alkyls perfluorés											
PFBA	249	0,40	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
PFPA	249	0,40	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
PFHxA	249	0,00	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
PFHpA	249	5,22	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0,168	[0,130 ; 0,240]
PFOA	249	100,00	1,564	[1,492 ; 1,640]	1,010	1,260	1,540	1,885	2,463	2,760	[2,520 ; 3,333]
PFNA	249	99,60	0,607	[0,572 ; 0,644]	0,370	0,452	0,570	0,757	1,040	1,349	[1,098 ; 1,910]
PFDA	249	71,08	0,243	[0,230 ; 0,256]	0,141	0,186	0,237	0,314	0,417	0,546	[0,447 ; 0,615]
PFUnA	249	95,58	0,117	[0,109 ; 0,125]	0,060	0,080	0,120	0,160	0,230	0,290	[0,240 ; 0,323]
PFDoA	249	8,03	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0,060	[0,040 ; 0,070]
Sulfonates d'alkyls perfluorés											
PFBS	249	0,00	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
PFHxS	249	99,60	0,793	[0,739 ; 0,851]	0,429	0,570	0,725	1,047	1,531	2,256	[1,655 ; 3,467]
PFHpS	249	3,21	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
PFOS	249	100,00	2,220	[2,058 ; 2,395]	1,120	1,550	2,000	2,947	4,922	6,124	[5,188 ; 8,259]
PFDS	249	0,40	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
Sulfamides d'alkyls perfluorés											
n-EtFOSAA	249	1,60	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC
n-MeFOSAA	249	21,29	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	0,091	0,130	[0,110 ; 0,186]
PFOSA	249	0,00	NC	NC	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	NC

NC : non calculé en raison du taux de censure important (>40 %)

Income and education

- Income categories
  - Low, N=497
  - Medium, N=821
  - High, N=679
- Education categories
  - < University, N=862
  - > University, N=1135

Compound	Income	GM	GSD
PFOS	Low	1.722	0.091
	Med	1.560	0.070
	High	1.573	0.086
PFOA	Low	1.270	0.060
	Med	1.262	0.043
	High	1.349	0.054
PFNA	Low	0.368	0.020
	Med	0.414	0.019
	High	0.441	0.028
PFHS	Low	0.580	0.055
	Med	0.542	0.041
	High	0.572	0.045

Compound	Education	GM	GSD
PFOS	< Univ.	1.592	0.075
	> Univ.	1.616	0.073
PFOA	< Univ.	1.240	0.044
	> Univ.	1.332	0.049
PFNA	< Univ.	0.386	0.017
	> Univ.	0.428	0.021
PFHS	< Univ.	0.592	0.049
	> Univ.	0.543	0.033

- No clear trend
- No statistical difference between groups using adjusted p-value

Breastfeeding

- Breastfeeding (Y/N)
  - Yes, N=1741
  - No, N=217

Compound	Breastfeeding	GM	GSD
PFOS	Yes	1.662	0.065
	No	1.197	0.133
PFOA	Yes	1.340	0.042
	No	0.954	0.044
PFNA	Yes	0.419	0.017
	No	0.330	0.020
PFHS	Yes	0.586	0.034
	No	0.395	0.069

- Statistical differences for all compounds for the breastfeeding status
- Even after p-value adjustment (p = 0.004167)

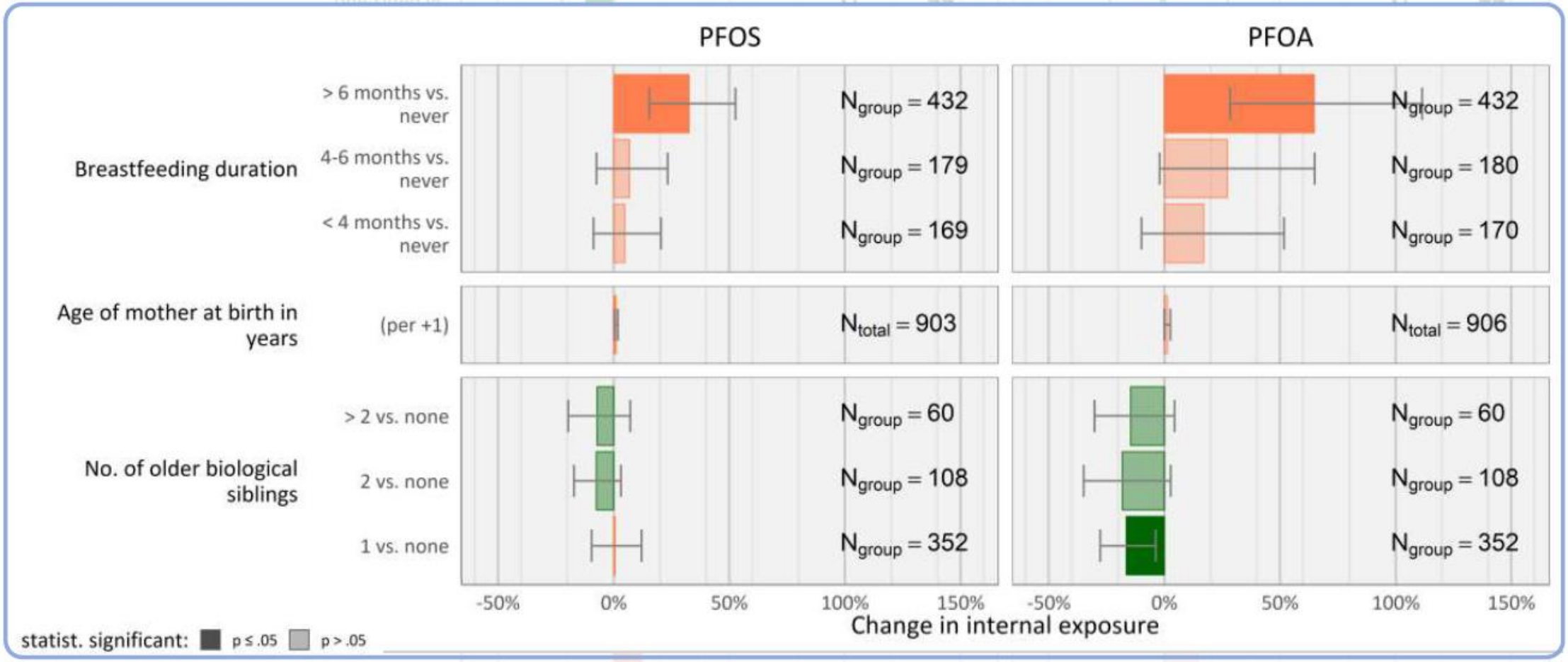
- Breastfeeding duration
  - < 7 months, N=655
  - > 7 months, N=1078

Compound	Breastfeeding	GM	GSD
PFOS	<7 mo.	1.441	0.080
	>7 mo.	1.803	0.072
PFOA	<7 mo.	1.138	0.032
	>7 mo.	1.470	0.054
PFNA	<7 mo.	0.368	0.014
	>7 mo.	0.450	0.022
PFHS	<7 mo.	0.497	0.035
	>7 mo.	0.642	0.038

- Statistical differences for all compounds for the breastfeeding duration
- Even after p-value adjustment (p = 0.004167)

Comparison with GerES V

Six months duration of breastfeeding was associated with higher PFOS and PFOA concentration in GerES V



BMI

- BMI categories
  - Underweight, N=85
  - Normal weight, N=1464
  - Overweight, N=258
  - Obese, N=175

- No statistical difference between groups
- PFAS concentrations are not associated with BMI

Compound	BMI	GM	GSD
PFOS	Underweight	1.748	0.266
	Normal weight	1.637	0.074
	Overweight	1.460	0.094
	Obese	1.524	0.078
PFOA	Underweight	1.415	0.158
	Normal weight	1.324	0.048
	Overweight	1.151	0.042
	Obese	1.236	0.084
PFNA	Underweight	0.484	0.102
	Normal weight	0.423	0.019
	Overweight	0.365	0.021
	Obese	0.357	0.023
PFHS	Underweight	0.608	0.111
	Normal weight	0.582	0.038
	Overweight	0.463	0.047
	Obese	0.536	0.046

Seafood consumption

- Frenquency of seafood consumption in the last month
  - 0, N=1260
  - 1, N=265
  - 2, N=189
  - 3+, N=283

- Concentrations increase with the frequency of seafood consumption
- Statistical differences for all compounds except PFHS

Compound	# times	GM	GSD
PFOS	0	1.477	0.067
	1	1.658	0.099
	2	1.781	0.147
	3+	2.188	0.137
PFOA	0	1.224	0.035
	1	1.281	0.059
	2	1.569	0.168
	3+	1.535	0.080
PFNA	0	0.369	0.013
	1	0.421	0.023
	2	0.530	0.058
	3+	0.580	0.051
PFHS	0	0.548	0.043
	1	0.560	0.046
	2	0.573	0.054
	3+	0.636	0.044

Discussion

Summary of findings

- Only 4 PFAS out of 9 were detected/quantified in plasma samples
- No significance: Age, Sex, Income, Education, BMI
- Significant differences: breastfeeding and duration, seafood consumption

Analyses are still ongoing

→ Multivariate analysis to assess the relative contribution of each factor/source of exposure

Next cycles: recruitment of children at 1y

→ Additional data on the first years of exposure

Thanks to

- Meng-Shan Tsai, post-doc UdeM
- Yvette Bonvalot, Santé Canada and UdeM
- Annie St-Amand, Santé Canada and UdeM
- Marc-André Verner, UdeM

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