

Supplementary materials

for

Profile of per- and polyfluoroalkyl substances, source appointment, and determinants in Argentinean postpartum women

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Table of contents

Table S1. List of PFAS analyzed with related chemical formula and acronym	Page 3
Table S2. Characteristic of the dietary intake by study region. The EMASAR study, 2011–2012	Page 4
Table S3. Limit of detections and detection frequencies of PFAS substances by region in the EMASAR study, 2011–2012 (n = 689)	Page 5
Table S4. Maternal serum concentrations (ng/mL) of per- and polyfluoroalkyl substances of the entire study group (n = 689) in the EMASAR study, 2011–2012	Page 6
Table S5. Pearson correlations (r) between serum concentrations of frequently detected PFAS by region in the EMASAR study, 2011–2012	Page 7
Table S6. Rotated component matrix of log ₁₀ -transformed PFAS with detection above 20% and correlation > 0.3, by region in the EMASAR study, 2011–2012 ^a	Page 8
Table S7. Beta coefficient and the varimax factor loadings' contribution relative to each substance as observed in the APCS-MLR model by region. The EMASAR study, 2011-2012	Page 9
Table S8. By region, multiple linear regression of PCA factor score with respective PFAS substances with loadings > 0.5 as independent variables. The EMASAR study in Argentina, 2011–2012.	Page 10
Table S9. A backward linear regression model with robust standard errors of maternal log ₁₀ -PFAS (ng/mL) serum concentrations with obstetric history, socio-demography, and diet as predictors. The EMASAR study in Argentina, 2011–2012.	11-12

Table S1. List of PFAS analysed with related chemical formula and acronym

	Acronym	Compound	Per- and polyfluoroalkyl substances -PFAS
C ₃ F ₇ COOH	PFBA	perfluorobutanoic acid	
C ₄ F ₉ COOH	PFPeA	perfluoropentanoic acid	
C ₅ F ₁₁ COOH	PFHxA	perfluorohexanoic acid	
C ₆ F ₁₃ COOH	PFHpA	perfluoroheptanoic acid	
C ₇ F ₁₅ COOH	PFOA	perfluorooctanoic acid	
C ₈ F ₁₇ COOH	PFNA	perfluorononanoic acid	
C ₉ F ₁₉ COOH	PFDA	perfluorodecanoic acid	
C ₁₀ F ₂₁ COOH	PFUnDA	perfluoroundecanoic acid	
C ₁₁ F ₂₃ COOH	PFDoDA	perfluorododecanoic acid	
C ₁₂ F ₂₅ COOH	PFTTrDA	perfluorotridecanoic acid	
C ₁₃ F ₂₇ COOH	PFTeDA	perfluorotetradecanoic acid	
C ₄ F ₉ SO ₃ H	PFBS	perfluorobutane sulfonic acid	
C ₅ F ₁₁ SO ₃ H	PFPeS	perfluoropentane sulfonic acid	
C ₆ F ₁₃ SO ₃ H	PFHxS	perfluorohexane sulfonic acid	
C ₇ F ₁₅ SO ₃ H	PFHpS	perfluoroheptane sulfonic acid	
C ₈ F ₁₇ SO ₃ H	PFOS	perfluorooctane sulfonic acid	
C ₉ F ₁₉ SO ₃ H	PFNS	perfluorononane sulfonic acid	
C ₁₀ F ₂₁ SO ₃ H	PFDS	perfluorodecane sulfonic acid	
C ₁₂ F ₂₅ SO ₃ H	PFDoDS	perfluorododecane sulfonic acid	
	PFOSA	perfluorooctane sulfonamide	perfluorooctane sulfonamide (FOSA)
C ₄ F ₉ CH ₂ CH ₂ SO ₃ H	4:2 FTSA	fluorotelomer sulfonic acids 4:2	fluorotelomer sulfonic acids (FTSAs)
C ₆ F ₁₃ CH ₂ CH ₂ SO ₃ H	6:2 FTSA	fluorotelomer sulfonic acids 6:2	
C ₈ F ₁₇ CH ₂ CH ₂ SO ₃ H	8:2 FTSA	fluorotelomer sulfonic acids 8:2	
C ₁₀ F ₂₁ CH ₂ CH ₂ SO ₃ H	10:2 FTSA	fluorotelomer sulfonic acids 10:2	

References:

<https://pfas-1.itrcweb.org/acronyms/> Buck, 2011

OECD: <https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/terminology-per-and-polyfluoroalkyl-substances.pdf>

Table S2. Characteristic of the dietary intake by study region. The EMASAR study, 2011–2012

		Ushuaia n = 193	Salta n = 496	
		Mean, SD or n (%)	Mean, SD or n (%)	P-value
Drinking water	Public	157 (81.3)	489 (98.6)	< 0.001
	Well, rain, river	1 (0.5)	7 (1.4)	0.453
Bottled water	Never/seldom		176 (35.5)	< 0.001
	Seldom	39 (20.2)	120 (24.2)	
	At least once a week	49 (25.4)	41 (8.3)	
	Almost every day	105 (54.4)	153 (30.8)	
<i>Dietary habits during pregnancy</i>^a		%	%	
Freshwater fish	never/seldom	81.9	76.5	0.129
	weekly/daily	18.1	23.5	
Saltwater fish	never/seldom	69.9	97.1	< 0.001
	weekly/daily	30.1	2.9	
Seafood	never/seldom	81.9	99	< 0.001
	weekly/daily	18.1	1	
Processed meat	never/seldom	62.2	43.9	< 0.001
	weekly/daily	37.8	56.1	
Egg	never/seldom	35.2	11.1	< 0.001
	weekly/daily	64.8	88.8	
Dairy	never/seldom	6.2	16.5	< 0.001
	weekly/daily	93.8	83.5	
Bread	never/seldom	30.1	3.1	< 0.001
	weekly/daily	69.9	96.9	
Cereals/pasta	never/seldom	5.2	1.8	0.017
	weekly/daily	94.8	98.2	

^a Meat, poultry, fruit, and vegetables, no significant differences, 90-98% intake daily or weekly; ^b Chi-square; SD, standard deviation

Table S3. Limit of detections (ng/mL) and detection frequencies (%) of PFAS substances by region in the EMASAR study, 2011–2012 (n = 689)

	Formula	Overall		Ushuaia (n = 193)		Salta (n = 496)			
		Mean LOD	% > LOD	Mean LOD	% > LOD	Mean LOD	% > LOD		
PFCA	C ₃ F ₇ COOH	PFBA	0.025	68.1	0.026	88.1	0.024	60.3	
	C ₄ F ₉ COOH	PFPeA	0.013	3.5	0.016	1	0.011	4.4	
	C ₅ F ₁₁ COOH	PFHxA	0.012	85.8	0.012	58.5	0.012	96.4	
	C ₆ F ₁₃ COOH	PFHpA	0.009	28.6	0.009	19.7	0.010	32.1	
	C ₇ F ₁₅ COOH	PFOA	0.017	92.6	0.016	100	0.017	89.7	
	C ₈ F ₁₇ COOH	PFNA	0.009	94.5	0.010	99.5	0.009	92.7	
	C ₉ F ₁₉ COOH	PFDA	0.010	84.2	0.010	85.5	0.010	85.5	
	C ₁₀ F ₂₁ COOH	PFUnDA	0.009	28.9	0.010	53.9	0.009	19.2	
	C ₁₁ F ₂₃ COOH	PFDoDA	0.010	11.3	0.010	5.7	0.009	13.5	
	C ₁₂ F ₂₅ COOH	PFTTrDA	0.015	2.6	0.014	2.6	0.015	2.6	
	C ₁₃ F ₂₇ COOH	PFTeDA	0.031	1.2	0.032	1	0.031	1.2	
	PFSA	C ₄ F ₉ SO ₃ H	PFBS	0.005	ND		ND		ND
		C ₅ F ₁₁ SO ₃ H	PFPeS	0.004	0.4	0.003	ND	0.004	0.6
C ₆ F ₁₃ SO ₃ H		∑PFHxS	0.007	98.4	0.006	99.5	0.007	98	
C ₇ F ₁₅ SO ₃ H		∑PFHpS	0.004	33.5	0.004	55.4	0.004	25	
C ₈ F ₁₇ SO ₃ H		∑PFOS	0.009	100	0.008	100	0.009	100	
C ₉ F ₁₉ SO ₃ H		∑PFNS	0.003	ND		ND		ND	
C ₁₀ F ₂₁ SO ₃ H		∑PFDS	0.003	ND		ND		ND	
C ₁₂ F ₂₅ SO ₃ H		PFDoDS	0.003	ND		ND		ND	
FTS		PFOSA	0.004	ND		ND		ND	
	C ₄ F ₉ CH ₂ CH ₂ SO ₃ H	4:2 FTSA	0.009	0.4	0.008	0.5	0.009	0.4	
	C ₆ F ₁₃ CH ₂ CH ₂ SO ₃ H	6:2 FTSA	0.007	4.2	0.008	3.6	0.007	4.4	
	C ₈ F ₁₇ CH ₂ CH ₂ SO ₃ H	8:2 FTSA	0.007	4.5	0.009	1.6	0.006	5.6	
	C ₁₀ F ₂₁ CH ₂ CH ₂ SO ₃ H	10:2 FTSA	0.007	0.1	0.008	0.5	0.006	ND	

For abbreviations of the PFAS, see Table S1. ND, no detection above LOD

Table S4. Maternal serum concentrations (ng/mL) of per- and polyfluoroalkyl substances of the entire study group (n = 689) in the EMASAR study, 2011–2012

Detection > 28%	Geometric	Arithmetic	SD	Minimum	Median	Maximum	% >
	Mean	Mean					LOD
PFBA	0.05	0.07	0.05	0.01	0.06	0.29	68.1
PFHxA	0.06	0.08	0.07	0.00	0.07	0.47	85.8
PFHpA	0.01	0.01	0.01	0.01	0.00	0.10	28.6
PFOA	0.11	0.16	0.19	0.00	0.12	2.90	92.6
PFNA	0.04	0.05	0.05	0.004	0.04	1.14	94.5
PFDA	0.02	0.03	0.03	0.004	0.02	0.55	84.2
PFUnDA	0.009	0.013	0.006	0.015	0.001	0.182	28.9
linear PFHxS	0.05	0.07	0.14	0.002	0.05	3.20	98.0
∑PFHxS	0.20	0.25	0.20	0.002	0.20	3.30	98.4
linear PFHpS	0.005	0.009	0.004	0.020	0.001	0.445	33.4
∑PFHpS	0.005	0.013	0.004	0.027	0.001	0.526	33.5
linear PFOS	0.40	0.54	1.38	0.06	0.40	33.1	100
∑PFOS	0.74	0.98	2.48	0.11	0.74	59.8	100
Detection < 12%				Minimum	Median	Maximum	% >
							LOD
PFPeS				0.001	0.003	0.014	0.4
PFPeA				0.002	0.010	0.076	3.5
PFDoDA				0.004	0.006	0.049	11.3
PFTrDA				0.003	0.010	0.052	2.6
PFTeDA				0.002	0.019	0.084	1.2
4:2 FTSA				0.001	0.004	0.033	0.4
6:2 FTSA				0.001	0.004	0.501	4.2
8:2 FTSA				0.001	0.004	0.051	4.5
10:2 FTSA				0.001	0.005	0.014	0.1

GM, geometric mean; LOD, limit of detection; SD, standard deviation

Substances non-detected (100 % < LOD) were PFBS, ∑PFNS, ∑PFDS, PFDoDS, PFOSA

For abbreviations of the PFAS, see Table S1

Table S5. Pearson correlations (r) between serum concentrations of frequently detected PFAS by region in the EMASAR study, 2011–2012

Region		PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUDA	PFHxS	PFHpS	PFOS
Ushuaia n = 193	PFBA	-.171*	-0.0001	-0.091	-0.141	-0.037	-0.065	-0.101	-.164*	-0.086
	PFHxA		-0.116	.389**	.399**	0.033	-0.110	.443**	.441**	.374**
	PFHpA			.179*	.216**	.228**	.194**	0.036	0.018	0.020
	PFOA				.659**	.397**	.196**	.369**	.491**	.504**
	PFNA					.568**	.338**	.331**	.438**	.431**
	PFDA						.462**	0.061	.219**	.238**
	PFUDA							-0.019	0.125	.189**
	PFHxS								.361**	.414**
	PFHpS									.678**
City		PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUDA	PFHxS	PFHpS	PFOS
Salta n = 496	PFBA	.340**	.277**	.245**	.232**	.212**	-0.056	.183**	0.084	.176**
	PFHxA		.236**	.541**	.359**	.182**	.140**	.244**	.135**	.373**
	PFHpA			.169**	.230**	.141**	0.086	.138**	.096*	.176**
	PFOA				.479**	.405**	.240**	.290**	.299**	.468**
	PFNA					.492**	.305**	.255**	.298**	.489**
	PFDA						.394**	.213**	.349**	.493**
	PFUDA							0.037	.224**	.319**
	PFHxS								.192**	.313**
	PFHpS									.536**

* Correlation is significant at the *** 0.001 level; ** 0.01 level; * 0.05 level; (2-tailed)

For abbreviations of the PFAS, see Table S1

Table S6. Rotated component matrix of log10-transformed PFAS with detection above 20% and correlation > 0.3, by region in the EMASAR study, 2011–2012^a

PFAS ^b	Ushuaia (n = 193)		Salta (n = 496)	
	VF1 ^c	VF2 ^c	VF1 ^c	VF2 ^c
∑PFHxS	0.715	-0.075	∑PFHxS	0.519
∑PFHpS	0.756	0.205	∑PFHpS	0.655
∑PFOS	0.734	0.258	∑PFOS	0.714
PFBA			PFBA	-0.092
PFHxA	0.772	-0.131	PFHxA	0.156
PFOA	0.659	0.454	PFOA	0.455
PFNA	0.559	0.635	PFNA	0.592
PFDA	0.111	0.841	PFDA	0.720
PFUnDA	-0.093	0.796	PFUnDA	0.716
KMO ^d	0.794		0.809	
Bartlett`s test, p-value	< 0.001		< 0.001	
Total variance, % ^e	43.84	19.5	38.53	14.21

^aExtraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 3 iterations; ^bFor abbreviations of the PFAS substances, see manuscript; ^cVF, Varimax Factor loading component; Factor loading was evaluated as strong (> 0.75), moderate (0.5-0.75), or weak < 0.05-0.3) (Cho et al., 2022);

^dKayser-Meyer-Olkin; ^eInitial eigenvalues % of variance

Table S7. Beta coefficient and the varimax factor loadings' contribution relative to each substance as observed in the APCS-MLR model by region.
The EMASAR study, 2011-2012

Ushuaia		PFHxA		PFOA		PFNA		PFDA		PFUNDA		PFHxS		PFHpS		PFOS			
		B	%	B	%	B	%	B	%	B	%	B	%	B	%	B	%		
VF1		0.542	85.5	0.176	59.3	0.133	46.8	0.037	11.6	-0.032	10	0.207	90.5	0.476	78.6	0.172	74.0		
VF2		-0.092	15	0.121	40.7	0.151	53.2	0.279	88.4	0.275	89.6	-0.022	9,5	0.129	21.4	0.060	26.0		
Salta		PFBA	PFHxA		PFOA		PFNA		PFDA		PFUNDA		PFHxS		PFHpS		PFOS		
		B	%	B	%	B	%	B	%	B	%	B	%	B	%	B	%		
VF1		-0.037	11.2	0.049	17.2	0.190	42.3	0.170	57.3	0.210	76.4	0.169	82.9	0.061	25.1	0.327	86.3	0.189	65.8
VF2		0.293	88.8	0.234	82.8	0.258	57.7	0.126	42.7	0.065	23.6	-0.035	17.1	0.181	74.9	0.052	13.7	0.098	34.2

B, beta coefficient; VF; regression factor scores from the PCA. For abbreviations of the PFAS, see Table S1.

Table S8. By region, multiple linear regression of PCA factor score with respective PFAS substances with loadings > 0.5 as independent variables. The EMASAR study in Argentina, 2011–2012.

City	Dependent variable	Regression Equations	R2	Standard Error of the Estimates	P-value
Salta	Factor 1	7.712 + 0.622[PFHpS] + 0.798[PFOS] + 0.936[PFDA] + 0.452[PFNA] + 1.834[PFUnDA]	0.938	0.251	< 0.001
	Factor 2	4.322 + 0.799[PFHxS] + 1.185[PFBA] + 1.341[PFHxA] + 0.477[PFOA]	0.924	0.276	< 0.001
Ushuaia	Factor 1	2.775 + 1.066[PFHxS] + 0.405[PFHpS] + 0.888[PFOS] + 0.544[PFHxA] + 0.651[PFOA] - 0.046[PFNA]	0.968	0.181	< 0.001
	Factor 2	6.100 + 0.743[PFNA] + 1.534[PFDA] + 1.454[PFUnDA]	0.939	0.247	< 0.001

For abbreviations of the PFAS, see Table S1

Table S9. A backward linear regression model with robust standard errors of maternal log₁₀-PFAS (ng/mL) serum concentrations with obstetric history, socio-demography, and diet as predictors. The EMASAR study in Argentina, 2011–2012.

log PFBA	Parameter	B	SE B ^b	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-0.681	0.096				
	Region (Ushuaia - Salta)	-0.242	0.030	0.57	0.50	0.66	< 0.001
	Seafood ^d	-0.110	0.050	0.78	0.62	0.97	0.027
	Poultry ^d	-0.189	0.050	0.65	0.52	0.81	< 0.001
	Dairy (milk) ^d	0.098	0.046	1.25	1.02	1.54	0.033
	Fruit ^d	-0.144	0.050	0.72	0.57	0.90	0.004
Adjusted R = 0.107. Modified Breusch-Pagan test, p-value < 0.001							
log PFHxA	Parameter	B	SE B ^b	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-1.617	0.173				
	Para 1 - multiparous	-0.113	0.049	0.77	0.62	0.96	0.021
	Lifetime lactation (per 6 months)	-0.013	0.001	0.94	1.00	1.00	0.023
	Age mother (per 10 years)	0.094	0.003	1.24	1.06	1.46	0.007
	Region (Ushuaia - Salta)	0.239	0.061	1.74	1.32	2.29	< 0.001
	Bottled water almost daily (no - yes)	0.102	0.037	1.27	1.07	1.50	0.006
	Freshwater fish ^d	-0.098	0.040	0.80	0.67	0.96	0.015
	Saltwater fish ^d	0.144	0.085	1.39	0.95	2.05	0.092
	Seafood ^d	-0.278	0.110	0.53	0.32	0.87	0.011
	Meat ^d	-0.157	0.063	0.70	0.52	0.93	0.013
	Egg ^d	0.114	0.056	1.30	1.01	1.67	0.042
	Vegetables ^d	-0.314	0.077	0.49	0.34	0.69	< 0.001
	Fruit ^d	0.163	0.067	1.46	1.07	1.97	0.015
Adjusted R = 0.136. Modified Breusch-Pagan test, p-value < 0.001							
log PFOA	Parameter	B	SE B ^b	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-0.122	0.116				
	Para 1 - multiparous	-0.257	0.035	0.55	0.47	0.65	< 0.001
	Lifetime lactation (per 6 months)	-0.014	0.001	0.97	0.95	0.99	0.001
	Age mother (per 10 years)	0.079	0.003	1.20	1.07	1.35	0.002
	Region (Ushuaia - Salta)	-0.413	0.033	0.39	0.33	0.45	< 0.001
	People household (number)	-0.011	0.004	0.98	0.96	0.99	0.013
	Bottled water almost daily (no - yes)	0.063	0.028	1.16	1.02	1.31	0.026
	Vegetables ^d	-0.125	0.068	0.75	0.55	1.02	0.067
Adjusted R = 0.393. Modified Breusch-Pagan test, p-value < 0.0							
log PFNA	Parameter	B	SE B	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-1.074	0.062				
	Para 1 - multiparous	-0.074	0.016	0.84	0.78	0.91	< 0.001
	Age mother (per 10 years)	0.024	0.001	1.06	1.0004	1.12	0.048
	Region (Ushuaia - Salta)	-0.138	0.019	0.73	0.67	0.79	< 0.001
	Freshwater fish ^d	0.033	0.017	1.08	0.997	1.17	0.061
	Saltwater fish ^d	0.053	0.030	1.13	0.99	1.30	0.081
	Processed meat ^d	-0.044	0.014	0.90	0.85	0.96	0.002
	Dairy (milk) ^d	0.036	0.020	1.09	0.99	1.19	0.073
	Vegetables ^d	-0.108	0.033	0.78	0.67	0.91	0.001

Excluded 35 influential cases. Adjusted R = 0.222. Modified Breusch-Pagan test, p-value < 0.001							
log PFDA	Parameter	B	SE B	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-1.580	0.049				
	Region (Ushuaia - Salta)	0.057	0.029	1.14	0.9996	1.30	0.051
	People household (number)	-0.011	0.004	0.98	0.96	0.99	0.004
	Freshwater fish ^d	0.074	0.028	1.19	1.04	1.35	0.008
	Processed meat ^d	-0.053	0.024	0.89	0.80	0.99	0.026
	Bread ^d	-0.115	0.041	0.77	0.64	0.92	0.005
Adjusted R = 0.042. Modified Breusch-Pagan test, p-value 0.069							
log PFHxS	Parameter	B	SE B	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-0.898	0.072				
	Para 1 - multiparous	-0.100	0.020	0.79	0.73	0.87	< .001
	Migrated (no - yes)	0.075	0.026	1.19	1.05	1.34	0.005
	Region (Ushuaia-Salta)	0.138	0.028	1.37	1.21	1.56	< .001
	Bread ^d	-0.060	0.035	0.87	0.74	1.02	0.088
Excluded 10 influential cases. Adjusted R = 0.063. Modified Breusch-Pagan test, p-value 0.442							
log PFOS	Parameter ^a	B	SE B	Ratio 10 ^c	Ratio 95 % CI ^c		p-value
	Intercept	-0.194	0.053				< 0.001
	Age mother (per 10 years)	0.086	0.002	1.22	1.14	1.31	< 0.001
	Para 1 - multiparous	-0.077	0.022	0.84	0.76	0.93	0.001
	Lifetime lactation (per 6 months)	-0.011	0.0004	0.97	0.96	0.99	< 0.001
	People household (number)	-0.007	0.003	0.98	0.97	1.00	0.011
	Freshwater fish ^d	0.048	0.021	1.12	1.02	1.23	0.020
	Bread ^d	-0.074	0.028	0.84	0.74	0.96	0.008
Excluded 5 influential cases. Adjusted R = 0.127. Modified Breusch-Pagan test, p-value 0.953							

a Backward regression with initial variables: age (year), parity (parous - multiparous), lactation (interval), region (Ushuaia - Salta), people in the household (number), education (primary/secondary - tertiary/university), migration inland or from abroad (no/yes), bottled water daily (no-yes), dietary factors during pregnancy (never/seldom - weekly/daily): freshwater fish, saltwater fish, seafood, meat, poultry, processed meat, egg, dairy products (milk), butter/cheese, vegetables (bean, tomato, garlic), fruit, bread.

b Robust standard error, p-value is calculated by the robust standard error

c Ratio corresponds to 10 beta.

d Never/seldom vs. weekly/daily

For abbreviations PFAS, see Table S1; B, beta coefficient; SE; standard error; CI, confidence interval