Assessing Per- and polyfluoroalkyl substance (PFAS) Exposure from Cell Phone Contact: Supporting Information

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Table S1: Mass transitions and collision energies for PFAS, detected by LC-MS/MS.

Compound	Parent Mass (m/z)	Daughter Mass (m/z)	Qualifying Mass (m/z)	Collision Energy (V)	Cone Energy (V)
PFBA	213.0	169.2	-	10	20
PFPeA	263.0	219.3	-	5	15
PFHxA	313.0	269.2	119.0	10	15
PFHpA	363.1	319.0	169.0	6	21
PFOA	413.1	369.0	169.0	11	22
PFNA	463.1	419.0	219.0	11	24
PFDA	513.2	469.0	269.0	11	26
PFUnDA	563.0	519.0	269.0	13	15
PFDoDA	613.0	569.0	169.0	13	20
PFTrDA	663.0	619.0	-	15	22
PFTeDA	713.0	669.0	-	14	15
PFHxDA	813.0	769.0	-	15	25
PFODA	913.0	869.0	-	15	25
MPFBA	217.0	172.0	-	8	10
MPFHxA	315.0	270.0	-	9	10
M4 PFOA	417.0	372.0	-	11	15
MPFNA	468.0	423.0	-	11	15
MPFDA	515.0	470.0	-	13	15
MPFUnDA	565.0	520.0	-	13	15
MPFDoDA	615.0	570.0	-	13	20
PFBS	299.0	80.2	99.0	30	45
PFHxS	399.1	80.2	99.0	36	55
PFOS	499.1	79.9	98.96	42	65
PFDS	599.0	99.0	-	50	70

MPFHxS	403.0	103.0	-	30	50
MPFOS	503.0	98.8	-	45	70
6:2 monoPAP	443.1	97.3	423.0	25	10
8:2 monoPAP	543.1	97.2	523.0	20	16
10:2 monoPAP	643.2	97.2	623.0	21	14
6:2 diPAP	789.2	443.0	97.0	20	20
6:2/8:2 diPAP	889.3	443.0	543.0	23	14
8:2 diPAP	989.3	542.9	97.0	21	18
M+2 6:2 monoPAP	445.0	97.0	-	20	38
M+2 8:2 monoPAP	545.0	97.0	-	20	25
M+4 6:2 diPAP	793.0	445.0	-	16	45
M+4 8:2 diPAP	993.0	545.0	-	25	35

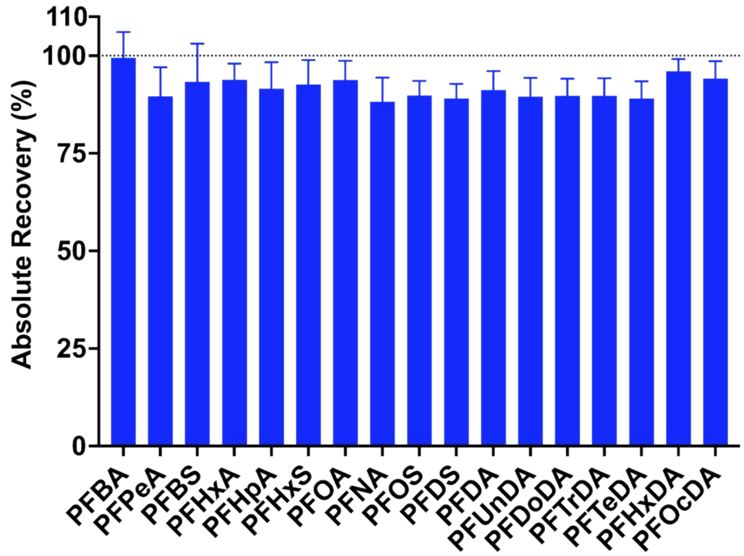

Figure S1: Absolute recoveries of PFCAs and PFSAs with standard deviation (n=3).

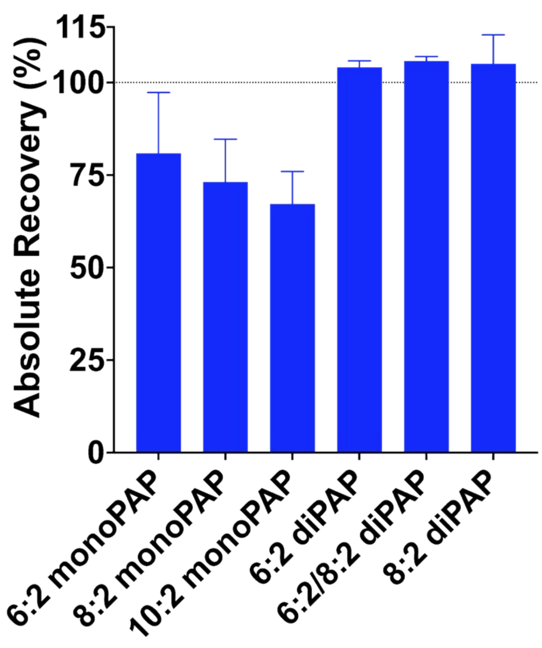

Figure S2: Absolute recoveries of PFCAs and PFSAs with standard deviation (n=3).

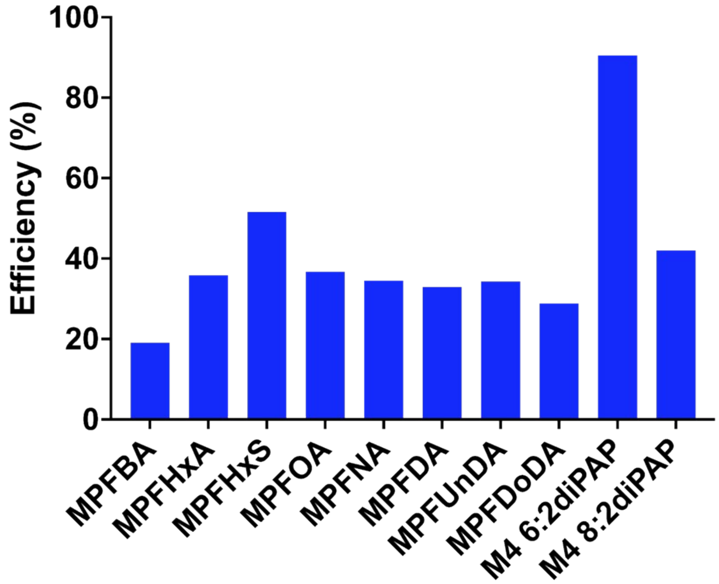

Figure S3: Efficiency of cell phone wipe using mass labeled PFAS (n=1).

Equation S1: Minimum detection limit (MDL)

MDL was calculated after every 80 samples.
If the analyte was detected in the procedural blanks (n=6): the MDL is defined as the concentration (determined by standard curve) yielding the mean response + 3-times the standard deviation of this response.

MDL = $\frac{\Sigma concentration\ in\ blanks}{6} + 3\sigma$

If the analyte was not detected in the procedural blanks: The equation below is used with the mass of the analyte in the standard (mean of n=6) generating a signal-to-noise ratio of at least 3.
MDL = (standard mass/signal area)x(noise)x3 = X ng

Equation S2: Minimum quantitation limit (MQL)

MQL was calculated after every 80 samples.
If the analyte was detected in procedural blanks (n=6): the MQL is defined as the concentration (determined by standard curve) yielding the mean response + 10-times the standard deviation of this response.

MQL = $\frac{\Sigma concentration\ in\ blanks}{6} + 10\sigma$

If the analyte was not detected in the procedural blanks: The equation below is used with the mass of the analyte in the standard (mean of n=6) generating a signal-to-noise ratio of at least 3.
MQL = (std mass/signal area)x(noise)x10 = X ng

Table S2: Average minimum detection limit (MDL) and minimum quantitation limit (MQL) for each analyte across 3 run days.

Chemical	MDL (ng)	MQL (ng)
PFBA	0.28	0.94
PFPeA	0.10	0.32
PFHxA	0.04	0.12
PFHpA	0.10	0.32
PFOA	0.03	0.08
PFNA	0.05	0.18
PFDA	0.04	0.14
PFUnDA	0.03	0.11
PFDoDA	0.03	0.09
PFTrDA	0.02	0.06
PFTeDA	0.03	0.11
PFHxDA	0.02	0.08
PFOcDA	0.03	0.1
PFBS	0.12	0.38
PFHxS	0.06	0.2
PFOS	0.14	0.47
PFDS	0.09	0.31
6:2monoPAP	0.42	1.4
8:2monoPAP	0.47	1.58
10:2 monoPAP	0.29	0.98
6:2 diPAP	0.05	0.17
6:2/8:2 diPAP	0.14	0.45
8:2 diPAP	0.17	0.58

SEM Results

In addition to common sources of exposure and the phasing out of products containing long-chain PFAS, particle size and elemental composition may also influence the correlations described between cell phone and hand wipes.[1,2] PFAAs have been shown to have particle size and composition dependent distribution based on evaporation and hydration ability.[2] Therefore, we performed scanning electron microscopy to assess particles on hand and cell phone wipes as a potential explanation for differences in compound abundance and mixture diversity.[1,2] There was no significant difference in particle size or element abundance, which supports the weak and moderate correlations seen between PFHxA, 6:2 diPAP and 6:2/8:2 diPAP between hand and cell phone wipes (Figure S4). The elemental particle composition was primarily organic, carbon and oxygen, with some particles containing metals and semimetals (*e.g.*, iron, calcium, sodium and silicon). Detection frequencies of elements had non-significant differences between cell phone and hand wipes. Further research is required to understand if some PFAS bind preferentially to metals or semimetals over others.

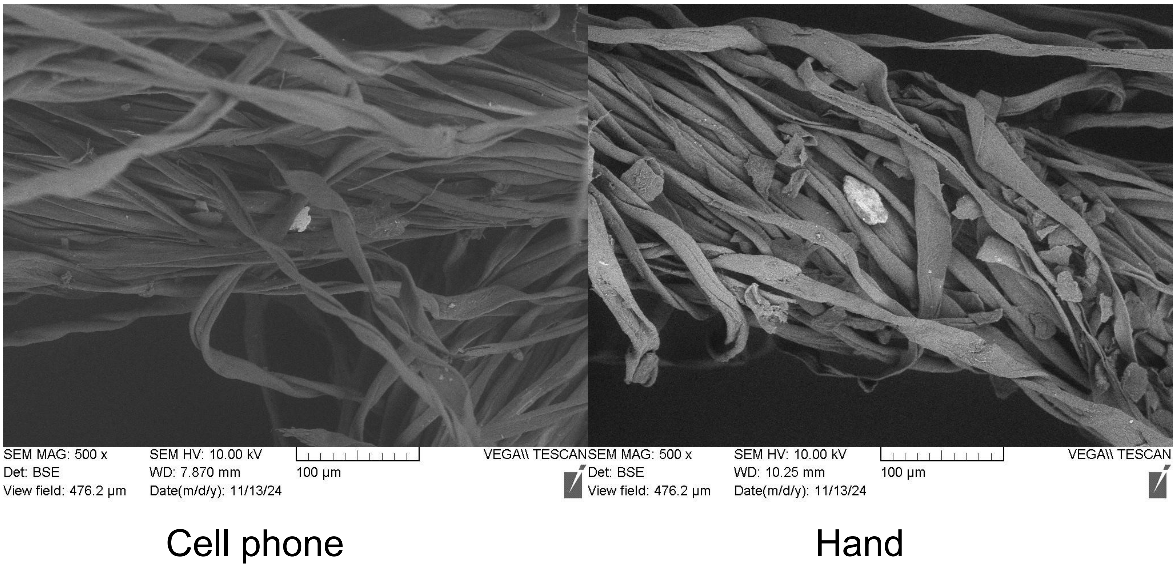

Figure S4: Representative SEM images from cell phone and hand wipes.

The complete set of images and elemental analysis can be found in the data repository: https://osf.io/mzjvn/?view_only=59153f7d4c124371a37c1315fbec8cce

Table S3: Descriptive statistics for PFAS measured on cell phone wipes, adjusted for wipe efficiency (ng) (n=118).

Chemical	n > MDL (%)	MDL < n < MQL (%)	Average (ng)	Median (ng)	25th percentile (ng)	75th percentile (ng)	Maximum (ng)
PFBA	1.7	1.7	< MDL	< MDL	< MDL	< MDL	2.62
PFPeA	5.9	5.1	< MDL	< MDL	< MDL	< MDL	1.43
PFHxA	50	26	0.34	< MDL	< MDL	0.41	4.30
PFHpA	4.2	2.5	< MDL	< MDL	< MDL	< MDL	0.41
PFOA	36	0.8	1.80	< MDL	< MDL	0.78	36.5
PFNA	1.7	1.7	< MDL	< MDL	< MDL	< MDL	0.18
PFDA	3.4	3.4	< MDL	< MDL	< MDL	< MDL	0.23
PFUnDA	2.5	1.7	< MDL	< MDL	< MDL	< MDL	1.15

PFDoDA	0.8	0.8	< MDL	< MDL	< MDL	< MDL	0.10
PFBS	0.8	0	< MDL	< MDL	< MDL	< MDL	1.11
PFHxS	0.8	0.8	< MDL	< MDL	< MDL	< MDL	0.22
PFOS	8.5	0	< MDL	< MDL	< MDL	< MDL	1.40
PFDS	1.7	1.7	< MDL	< MDL	< MDL	< MDL	0.02
6:2 monoPAP	0.8	0	< MDL	< MDL	< MDL	< MDL	2.66
8:2 monoPAP	20	13	0.56	< MDL	< MDL	< MDL	7.33
10:2 monoPAP	5.9	4.2	< MDL	< MDL	< MDL	< MDL	2.06
6:2 diPAP	94	15	2.33	0.44	0.18	1.40	53.4
6:2/8:2 diPAP	24	8.5	0.41	< MDL	< MDL	< MDL	15.1
8:2 diPAP	7.6	6.7	< MDL	< MDL	< MDL	< MDL	3.76
∑ PFAS (n=118)	99	—	5.79	1.96	0.86	4.60	96.2

Table S4: Descriptive statistics for PFASs measured on hand wipes (ng) (n=50).

Chemical	n > MDL (%)	MDL < n < MQL (%)	Average (ng)	Median (ng)	25th percentile (ng)	75th percentile (ng)	Maximum (ng)
PFBA	2	2	< MDL	< MDL	< MDL	< MDL	0.21
PFHxA	24	8	0.05	< MDL	< MDL	< MDL	0.49
PFHpA	2	2	< MDL	< MDL	< MDL	< MDL	0.03
PFOA	10	4	0.16	< MDL	< MDL	< MDL	3.97
PFNA	2	2	< MDL	< MDL	< MDL	< MDL	0.07

PFDA	2	2	< MDL	< MDL	< MDL	< MDL	0.09
PFUnDA	2	2	< MDL	< MDL	< MDL	< MDL	0.08
PFDoDA	2	0	< MDL	< MDL	< MDL	< MDL	0.07
PFTrDA	2	2	< MDL	< MDL	< MDL	< MDL	0.02
PFBS	2	0	< MDL	< MDL	< MDL	< MDL	0.43
PFOS	8	0	< MDL	< MDL	< MDL	< MDL	0.95
6:2 monoPAP	4	2	< MDL	< MDL	< MDL	< MDL	5.84
8:2 monoPAP	24	12	0.94	< MDL	< MDL	< MDL	26.94
10:2 monoPAP	8	2	0.37	< MDL	< MDL	< MDL	16.75
6:2 diPAP	96	16	4.3	0.75	0.21	1.8	93.06
6:2/8:2 diPAP	34	2	3.2	< MDL	< MDL	< MDL	104.14
8:2 diPAP	8	4	0.3	< MDL	< MDL	< MDL	12.22
∑ PFAS (n=50)	100	—	9.8	1.2	0.72	3.2	259.06

Table S5: Calculations of median EDA using weighted average dermal uptake factor (55%) resulted in a difference of less than 5% compared to calculations of mean EDA using compound specific dermal uptake factors (Equation S3).

	Median EDA using weighted average (ng/day)	Median EDA using compound specific calculation (ng/day)
Cell phone wipes	5.0	4.8
Hand wipes	15.3	14.6

Table S6: Comparison of study demographics to Ontario demographics (Government of Canada, 2022)

	Survey for Cell Phone Wipes (n=118)	Survey for Hand Wipes (n=50)	Ontario Population - StatsCan
Female	50.8%	46.0%	51.0%
Male	42.4%	42.0%	49.0%
Sex no response	6.78%	12.0%	-
15-65	84.8%	86.0%	65.6%
65+	8.48%	6.00%	18.5%
Age no response	6.78%	8.00%	-
White	49.2%	48.0%	65.7%
Asian	14.4%	16.0%	22.8%
Black	7.6%	8.0%	5.5%
Arab	21.2%	22.0%	2.0%
Other	7.6%	6.0%	4.0%

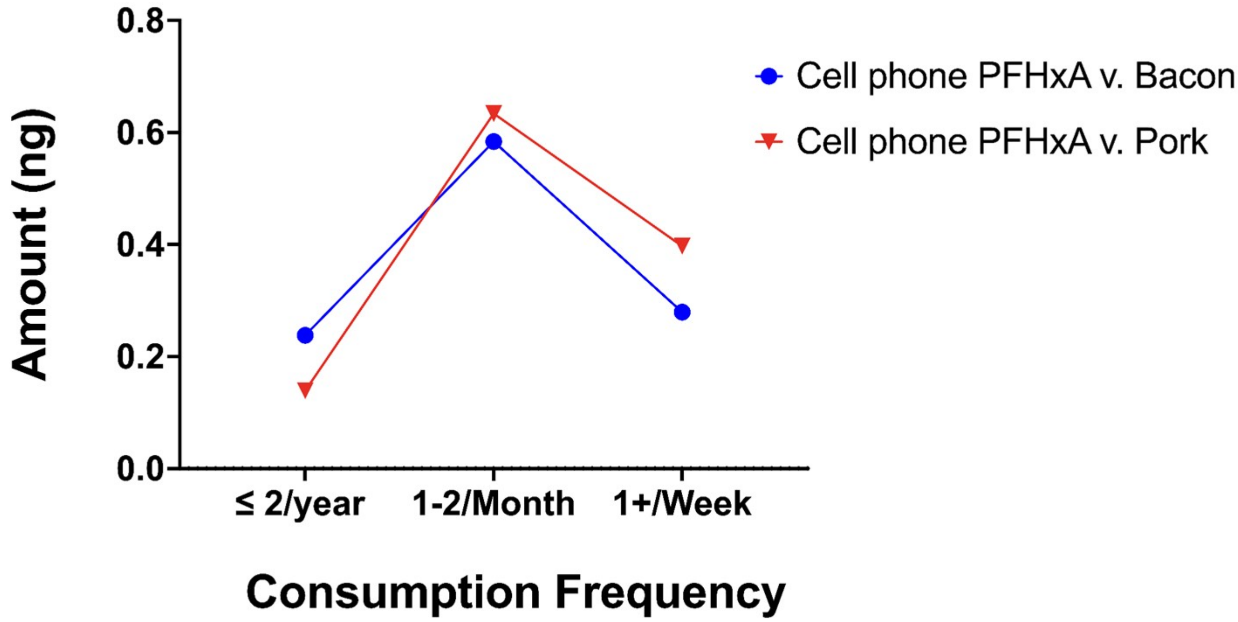

Figure S5: Dietary habits impact cell phone PFHxA levels. Averages of PFHxA between consumption frequency groups for bacon and pork ($p = 0.015$ and 0.0008). Statistical significance was determined by Kruskal-Wallis test.

References

1 H. Ge, E. Yamazaki, N. Yamashita, S. Taniyasu, A. Ogata and M. Furuuchi, Particle size specific distribution of perfluoro alkyl substances in atmospheric particulate matter in Asian cities, *Environ. Sci. Process. Impacts*, 2017, **19**, 549–560.

2 X. Li, Y. Wang, J. Cui, Y. Shi and Y. Cai, Occurrence and Fate of Per- and Polyfluoroalkyl Substances (PFAS) in Atmosphere: Size-Dependent Gas-Particle Partitioning, Precipitation Scavenging, and Amplification, *Environ. Sci. Technol.*, 2024, **58**, 9283–9291.