



PERFLUOROOCTANOIC ACID (PFOA)  
AND PERFLUOROOCTANESULFONIC  
ACID (PFOS)

VOLUME 135

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OF CARCINOGENIC HAZARDS  
TO HUMANS

**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference              | Occupational group | Geographic location | Sample collection year | Job, task, or subgroup description | Biological matrix | Analytical method | No. of participants | PFOA (ng/mL)  |               |                   |                            | PFOS (ng/mL)  |               |                   |                            | Comments  |
|------------------------|--------------------|---------------------|------------------------|------------------------------------|-------------------|-------------------|---------------------|---------------|---------------|-------------------|----------------------------|---------------|---------------|-------------------|----------------------------|---|
|                        |                    |                     |                        |                                    |                   |                   |                     | Mean (GM)     | Range         | Median (IQR)      | LOD (LOQ indicated with *) | Mean/GM       | Range         | Median (IQR)      | LOD (LOQ indicated with *) |   |
| Guruge et al. (2005)   | Agricultural       | Sri Lanka           | 2003                   | NR                                 | Serum             | LC-MS/MS          | 30                  | 6.38 (NR)     | (0.32–23.5)   | 4.02 (NR, NR)     | NR                         | 5.03 (NR)     | (0.35–18.2)   | 3.26 (NR, NR)     | NR                         |   |
| Guruge et al. (2005)   | Agricultural       | Sri Lanka           | 2003                   | NR                                 | Seminal plasma    | LC-MS/MS          | 30                  | 0.323 (NR)    | (LOD–1.71)    | 0.134 (NR, NR)    | 0.072                      | 0.118 (NR)    | (LOD–0.529)   | 0.103 (NR, NR)    | 0.01                       |   |
| Zhou et al. (2014)     | Fishery            | China               | 2012                   | NR                                 | Urine             | LC-MS             | 39                  | 0.134 (NR)    | (NR–NR)       | 0.108 (NR, NR)    | NR                         | 8.01 (NR)     | (NR–NR)       | 4.7 (NR, NR)      | NR                         | Potential for large dietary contribution from employer provided fish. PFOS reported as the sum of linear and branched isomers. Linear-PFOS measured in higher concentrations. |
| Zhou et al. (2014)     | Fishery            | China               | 2012                   | NR                                 | Serum             | LC-MS             | 39                  | 43.5 (NR)     | (NR–NR)       | 41 (NR, NR)       | NR                         | 11 400 (NR)   | (82.6–31 400) | 10 400 (NR, NR)   | NR                         | Potential for large dietary contribution from employer provided fish. PFOS reported as the sum of linear and branched isomers. Linear-PFOS measured in higher concentrations. |
| Lu et al. (2014)       | Barbers            | Tianjin, China      | 2012                   | NR                                 | Blood             | LC-ESI-MS/MS      | 49                  | 2.84 (NR)     | (0.71–12.18)  | NR (NR, NR)       | NR                         | 2.55 (NR)     | (0.44–7.72)   | NR (NR, NR)       | NR                         |   |
| Clarity et al. (2020)  | First Responders   | California, USA     | 2015                   | NR                                 | Serum             | LC-MS/MS          | 84                  | NR (1.13)     | (NR–NR)       | NR (NR, NR)       | 0.02                       | NR (4.33)     | (NR–NR)       | NR (NR, NR)       | 0.02                       | Female firefighters with at least 5 years experience  |
| Dobraca et al. (2015)  | First Responders   | California, USA     | 2011                   | NR                                 | Serum             | LC-MS             | 101                 | NR (3.75)     | (18.1–18.1)   | 3.86 (2.96, 4.89) | 0.301                      | NR (12.5)     | (NR–46.6)     | 12.7 (10.1, 16.8) | 0.083                      |   |
| Graber et al. (2021)   | First Responders   | New Jersey, USA     | 2019                   | NR                                 | Serum             | LC-MS/MS          | 116                 | NR (2.07)     | (NR–NR)       | NR (NR, NR)       | 0.1                        | NR (4.25)     | (NR–NR)       | NR (NR, NR)       | 0.1                        | Male volunteer population   |
| Jin et al. (2011)      | First Responders   | USA                 | 2006                   | NR                                 | Serum             | LC-MS/MS          | 36                  | 87.47 (37.69) | (0.25–7534.6) | 31.5 (NR, NR)     | 0.5                        | 29.18 (24.37) | (0.25–67.5)   | 27.85 (NR, NR)    | 0.5                        | Self-reported occupation of firefighter in C8 study cohort  |
| Laitinen et al. (2014) | First Responders   | Finland             | 2010                   | NR                                 | Serum             | LC-MS/MS          | 8                   | NR (NR)       | (1.61–4.85)   | 2.94 (NR, NR)     | NR                         | NR (NR)       | (2.79–35.8)   | 11.1 (NR, NR)     | NR                         | Exposure from aircraft response training with AFFF  |
| Leary et al. (2020)    | First Responders   | USA                 | 2019                   | Airport firefighters               | Serum             | LC-MS/MS          | 38                  | NR (NR)       | (1.1–4.65)    | 2.17 (NR, NR)     | NR                         | NR (NR)       | (4.28–30.42)  | 10.69 (NR, NR)    | NR                         |   |
| Leary et al. (2020)    | First Responders   | USA                 | 2019                   | Suburban firefighters              | Serum             | LC-MS/MS          | 9                   | NR (NR)       | (1.02–3.07)   | 1.72 (NR, NR)     | NR                         | NR (NR)       | (1.57–9.34)   | 4.04 (NR, NR)     | NR                         |   |
| Rotander et al. (2015) | First Responders   | Australia           | 2013                   | NR                                 | Serum             | LC-MS/MS          | 149                 | 4.6 (NR)      | (0.3–18)      | 4.2 (NR, NR)      | 0.05                       | 74 (NR)       | (3.4–391)     | 66 (NR, NR)       | 0.03                       | Firefighters stratified by use of AFFF products   |
| Shaw et al. (2013)     | First Responders   | California, USA     | 2009                   | NR                                 | Serum             | LC-MS/MS          | 12                  | 7 (NR)        | (2–12)        | 6 (NR, NR)        | 0                          | 12 (NR)       | (3–59)        | 9 (NR, NR)        | NR                         |   |
| Tao et al. (2008)      | First Responders   | New York, USA       | 2001                   | Symptomatic group                  | Plasma            | LC-MS             | 70                  | 13.4 (NR)     | (2.6–35.6)    | 12.3 (NR, NR)     | 0.5*                       | 33.6 (NR)     | (3.8–70.1)    | 31.4 (NR, NR)     | 0.5*                       | World Trade Center responders   |
| Tao et al. (2008)      | First Responders   | New York, USA       | 2001                   | Asymptomatic group                 | Plasma            | LC-MS             | 70                  | 12.6 (NR)     | (1.4–27.5)    | 11.7 (NR, NR)     | 0.5*                       | 33.9 (NR)     | (7.4–101)     | 29.2 (NR, NR)     | 0.5*                       | World Trade Center responders   |
| Tao et al. (2008)      | First Responders   | New York, USA       | 2001                   | More dust exposed group            | Plasma            | LC-MS             | 34                  | 6.15 (NR)     | (1.57–15.3)   | 5.11 (NR, NR)     | 0.5*                       | 27.2 (NR)     | (7.95–69.4)   | 22.1 (NR, NR)     | 0.5*                       | World Trade Center responders   |
| Tao et al. (2008)      | First Responders   | New York, USA       | 2001                   | Less dust exposed group            | Plasma            | LC-MS             | 34                  | 5.07 (NR)     | (2.19–10.6)   | 4.55 (NR, NR)     | 0.5*                       | 22.9 (NR)     | (12.6–60.7)   | 22.6 (NR, NR)     | 0.5*                       | World Trade Center responders   |

**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference                 | Occupational group        | Geographic location | Sample collection year | Job, task, or subgroup description | Biological matrix | Analytical method | No. of participants | PFOA (ng/mL)    |               |                       |                            | PFOS (ng/mL) |                |               |                            | Comments   |
|---------------------------|---------------------------|---------------------|------------------------|------------------------------------|-------------------|-------------------|---------------------|-----------------|---------------|-----------------------|----------------------------|--------------|----------------|---------------|----------------------------|--|
|                           |                           |                     |                        |                                    |                   |                   |                     | Mean (GM)       | Range         | Median (IQR)          | LOD (LOQ indicated with *) | Mean/GM      | Range          | Median (IQR)  | LOD (LOQ indicated with *) |  |
| Tao et al. (2008)         | First Responders          | New York, USA       | 2001                   | More smoke exposed group           | Plasma            | LC-MS             | 144                 | 10.21 (NR)      | (0.67–61)     | 8.42 (NR, NR)         | 0.5*                       | 28.6 (NR)    | (5.5–73.4)     | 25.3 (NR, NR) | 0.5*                       | World Trade Center responders  |
| Tao et al. (2008)         | First Responders          | New York, USA       | 2001                   | Less smoke exposed group           | Plasma            | LC-MS             | 131                 | 8.88 (NR)       | (1.91–35.4)   | 8.16 (NR, NR)         | 0.5*                       | 26.7 (NR)    | (3.91–185)     | 24.8 (NR, NR) | 0.5*                       | World Trade Center responders  |
| Burgess et al. (2023)     | First Responders          | USA                 | 2019                   | Department C males                 | Serum             | LC-MS/MS          | 59                  | NR (2.04)       | (0.6–7.5)     | 2.2 (NR, NR)          | 0.1                        | NR (6.62)    | (1.7–22.6)     | 6.6 (NR, NR)  | 0.1                        | Linear PFOA and linear PFOS reported. Municipal firefighters from 4 fire departments in SW, SE, and NW USA (290 participants total). |
| Burgess et al. (2023)     | First Responders          | USA                 | 2019                   | Department D males                 | Serum             | LC-MS/MS          | 61                  | NR (1.82)       | (0.3–3.8)     | 1.8 (NR, NR)          | 0.1                        | NR (3.69)    | (1.6–16)       | 3.7 (NR, NR)  | 0.1                        | Linear PFOA and linear PFOS reported. Municipal firefighters from 4 fire departments in SW, SE, and NW USA (290 participants total). |
| Gasiorowski et al. (2022) | First Responders          | Australia           | 2019                   | NR                                 | Serum             |                   | 285                 | NR (NR)         | (NR–NR)       | NR (NR, NR)           | NR                         | 4.9 (NR)     | (0–120)        | NR (NR, NR)   | NR                         | Screening level reported. RCT evaluating blood or plasma donation on PFAS serum concentrations                                       |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2000                   | NR                                 | Serum             | LC-MS/MS          | 25                  | 18 800 (11 700) | (1540–86 300) | 11 920 (5530, 32 000) | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2001                   | NR                                 | Serum             | LC-MS/MS          | 42                  | 19 700 (10 200) | (730–91 900)  | 11 070 (4350, 19 720) | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2002                   | NR                                 | Serum             | LC-MS/MS          | 46                  | 19 300 (9300)   | (340–91 900)  | 10 150 (4570, 20 800) | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2003                   | NR                                 | Serum             | LC-MS/MS          | 41                  | 13 700 (6900)   | (380–74 700)  | 6250 (4110, 14 200)   | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2004                   | NR                                 | Serum             | LC-MS/MS          | 34                  | 11 400 (6500)   | (540–46 300)  | 6820 (2840, 18 970)   | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2006                   | NR                                 | Serum             | LC-MS/MS          | 49                  | 10 800 (5800)   | (540–41 900)  | 5270 (2360, 16 310)   | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Costa et al. (2009)       | Fluorochemical production | Italy               | 2007                   | NR                                 | Serum             | LC-MS/MS          | 50                  | 11 600 (5400)   | (200–47 000)  | 3890 (2190, 18 660)   | NR                         | NR (NR)      | (NR–NR)        | NR (NR, NR)   | NR                         | PFOA production workers  |
| Fu et al. (2016)          | Fluorochemical production | China               | 2012                   | All workers                        | Serum             | LC-MS/MS          | 302                 | 1052 (NR)       | (2.5–32 000)  | 427 (NR, NR)          | 0.063                      | 5624 (NR)    | (50.3–118 000) | 1725 (NR, NR) | 0.018                      |  |
| Fu et al. (2016)          | Fluorochemical production | China               | 2012                   | Electrolytic department            | Serum             | LC-MS/MS          | 74                  | 2337 (NR)       | (55.9–32 000) | 1126 (NR, NR)         | 0.063                      | 1909 (NR)    | (234–8501)     | 1541 (NR, NR) | 0.018                      |  |
| Fu et al. (2016)          | Fluorochemical production | China               | 2012                   | Sulfonation department             | Serum             | LC-MS/MS          | 101                 | 929 (NR)        | (4.9–4630)    | 603 (NR, NR)          | 0.063                      | 14 002 (NR)  | (416–118 000)  | 5544 (NR, NR) | 0.018                      |  |
| Fu et al. (2016)          | Fluorochemical production | China               | 2012                   | Research building                  | Serum             | LC-MS/MS          | 27                  | 404 (NR)        | (4.7–2920)    | 142 (NR, NR)          | 0.063                      | 1195 (NR)    | (101–7450)     | 736 (NR, NR)  | 0.018                      |  |

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|---------------------|---------------------------|---------------------|------------------------|------------------------------------|-------------------|-------------------|---------------------|--------------|---------------|---------------|----------------------------|--------------|---------------|---------------|----------------------------|---|
|                     |                           |                     |                        |                                    |                   |                   |                     | Mean (GM)    | Range         | Median (IQR)  | LOD (LOQ indicated with *) | Mean/GM      | Range         | Median (IQR)  | LOD (LOQ indicated with *) |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Fabric finishing agent department  | Serum             | LC-MS/MS          | 8                   | 606 (NR)     | (51–2600)     | 114 (NR, NR)  | 0.063                      | 514 (NR)     | (103–1890)    | 267 (NR, NR)  | 0.018                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Management office                  | Serum             | LC-MS/MS          | 92                  | 362 (NR)     | (2.5–4380)    | 101 (NR, NR)  | 0.063                      | 1144 (NR)    | (50.3–7910)   | 616 (NR, NR)  | 0.018                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | All workers                        | Urine             | LC-MS/MS          | 274                 | 4.3 (NR)     | (LOD–53.6)    | 1.9 (NR, NR)  | 0.025                      | 4.4 (NR)     | (LOD–81.5)    | 1.2 (NR, NR)  | 0.007                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Electrolytic department            | Urine             | LC-MS/MS          | 67                  | 6.7 (NR)     | (LOD–38.4)    | 3.5 (NR, NR)  | 0.025                      | 1.8 (NR)     | (LOD–26.9)    | 0.93 (NR, NR) | 0.007                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Sulfonation department             | Urine             | LC-MS/MS          | 98                  | 4.8 (NR)     | (LOD–53.6)    | 2.7 (NR, NR)  | 0.025                      | 8.8 (NR)     | (LOD–81.5)    | 3 (NR, NR)    | 0.007                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Research building                  | Urine             | LC-MS/MS          | 25                  | 1.8 (NR)     | (LOD–15.3)    | 0.92 (NR, NR) | 0.025                      | 1.4 (NR)     | (LOD–6.5)     | 1.1 (NR, NR)  | 0.007                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Fabric finishing agent department  | Urine             | LC-MS/MS          | 8                   | 5.1 (NR)     | (1.2–22.2)    | 1.5 (NR, NR)  | 0.025                      | 0.39 (NR)    | (LOD–1.7)     | LOD (NR, NR)  | 0.007                      |   |
| Fu et al. (2016)    | Fluorochemical production | China               | 2012                   | Management office                  | Urine             | LC-MS/MS          | 76                  | 1.5 (NR)     | (LOD–9.7)     | 0.86 (NR, NR) | 0.025                      | 1.6 (NR)     | (LOD–12.1)    | 0.49 (NR, NR) | 0.007                      |   |
| Gao et al. (2015)   | Fluorochemical production | China               | 2012                   | NR                                 | Serum             | LC-MS/MS          | 36                  | 1090 (371)   | (2.66–14 774) | 537 (NR, NR)  | 0.03–0.5*                  | 4032 (1386)  | (47.3–62 898) | 1478 (NR, NR) | 0.08–0.25*                 | Multiple samples collected per participant. Concentrations presented are sum of isomers |
| Gao et al. (2015)   | Fluorochemical production | China               | 2012                   | NR                                 | Urine             | LC-MS/MS          | 36                  | 3.43 (1.82)  | (LOQ–24.3)    | 0.46 (NR, NR) | 0.01–0.08*                 | 1.94 (0.85)  | (LOQ–39.9)    | 1.81 (NR, NR) | 0.03–0.1*                  | Multiple samples collected per participant. Concentrations presented are sum of isomers |
| Olsen et al. (2007) | Fluorochemical production | USA                 | 1995                   | NR                                 | Serum             | LC-MS             | 26                  | 691 (NR)     | (72–5100)     | 408 (NR, NR)  | NR                         | 799 (NR)     | (145–3490)    | 626 (NR, NR)  | NR                         |   |
| Olsen et al. (2000) | Fluorochemical production | USA                 | 1993                   | NR                                 | Serum             | LC-MS/MS          | 111                 | 5000 (NR)    | (0–80 000)    | 1100 (NR, NR) | NR                         | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | Male workers involved in APFO production  |
| Olsen et al. (2000) | Fluorochemical production | USA                 | 1995                   | NR                                 | Serum             | LC-MS/MS          | 80                  | 6800 (NR)    | (0–114 100)   | 1200 (NR, NR) | NR                         | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | Male workers involved in APFO production  |
| Olsen et al. (2000) | Fluorochemical production | USA                 | 1997                   | NR                                 | Serum             | LC-MS/MS          | 74                  | 6400 (NR)    | (50–81 350)   | 1300 (NR, NR) | NR                         | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | Male workers involved in APFO production  |
| Olsen et al. (2003) | Fluorochemical production | Belgium             | 2000                   | NR                                 | Serum             | LC-MS/MS          | 255                 | 840 (330)    | (10–7040)     | NR (NR, NR)   | NR                         | 800 (440)    | (40–6240)     | NR (NR, NR)   | NR                         | 81% male  |
| Olsen et al. (2003) | Fluorochemical production | Alabama, USA        | 2000                   | NR                                 | Serum             | LC-MS/MS          | 263                 | 1780 (1130)  | (40–12 700)   | NR (NR, NR)   | NR                         | 1320 (910)   | (60–10 060)   | NR (NR, NR)   | NR                         | 82% male  |
| Olsen et al. (2003) | Fluorochemical production | Alabama, USA        | 1998                   | NR                                 | Serum             | LC-MS/MS          | 126                 | NR (899)     | (21–6160)     | NR (NR, NR)   | NR                         | (941)        | (91–10 600)   | NR (NR, NR)   | NR                         | Chemical plant workers  |
| Olsen et al. (2003) | Fluorochemical production | Alabama, USA        | 1998                   | NR                                 | Serum             | LC-MS/MS          | 60                  | NR (49)      | (6–298)       | NR (NR, NR)   | NR                         | (136)        | (15–946)      | NR (NR, NR)   | NR                         | Film plant workers (no fluorochemicals produced)  |
| Olsen et al. (1999) | Fluorochemical production | Belgium             | 1995                   | Antwerp facility                   | Serum             | LC-MS             | 88                  | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | 1930 (NR)    | (NR–NR)       | NR (NR, NR)   | NR                         | Male employees  |

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|-------------------------|---------------------------|---------------------|------------------------|------------------------------------|-------------------|-------------------------|---------------------|-------------------|-----------------|----------------------|----------------------------|---------------|---------------|--------------------|----------------------------|---|
|                         |                           |                     |                        |                                    |                   |                         |                     | Mean (GM)         | Range           | Median (IQR)         | LOD (LOQ indicated with *) | Mean/GM       | Range         | Median (IQR)       | LOD (LOQ indicated with *) |   |
| Olsen et al. (1999)     | Fluorochemical production | Belgium             | 1997                   | Antwerp facility                   | Serum             | LC-MS                   | 65                  | NR (NR)           | (NR–NR)         | NR (NR, NR)          | NR                         | 1480 (NR)     | (NR–NR)       | NR (NR, NR)        | NR                         | Male employees  |
| Olsen et al. (1999)     | Fluorochemical production | Alabama, USA        | 1997                   | Decatur facility                   | Serum             | LC-MS                   | 90                  | NR (NR)           | (NR–NR)         | NR (NR, NR)          | NR                         | 2440 (NR)     | (NR–NR)       | NR (NR, NR)        | NR                         | Male employees  |
| Olsen et al. (1999)     | Fluorochemical production | Alabama, USA        | 1997                   | Decatur facility                   | Serum             | LC-MS                   | 84                  | NR (NR)           | (NR–NR)         | NR (NR, NR)          | NR                         | 1960 (NR)     | (NR–NR)       | NR (NR, NR)        | NR                         | Male employees  |
| Sakr et al. (2007)      | Fluorochemical production | USA                 | 2004                   | Currently working in APFO areas    | Serum             | LC-MS/MS                | 259                 | 494 (NR)          | (17.4–9550)     | NR (NR, NR)          | 0.5*                       | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Sakr et al. (2007)      | Fluorochemical production | USA                 | 2004                   | Research/technical                 | Serum             | LC-MS/MS                | 160                 | 176 (NR)          | (8.1–2070)      | NR (NR, NR)          | 0.5*                       | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Sakr et al. (2007)      | Fluorochemical production | USA                 | 2004                   | Previously worked in APFO areas    | Serum             | LC-MS/MS                | 264                 | 195 (NR)          | (8.6–2590)      | NR (NR, NR)          | 0.5*                       | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Sakr et al. (2007)      | Fluorochemical production | USA                 | 2004                   | Never worked in APFO areas         | Serum             | LC-MS/MS                | 342                 | 114 (NR)          | (4.6–963)       | NR (NR, NR)          | 0.5*                       | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Steenland et al. (2009) | Fluorochemical production | Ohio Valley, USA    | 2006                   | Current employee                   | Serum             | LC-MS                   | 1171                | NR (NR)           | (NR–NR)         | 147.8 (NR, NR)       | 0.5                        | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Steenland et al. (2009) | Fluorochemical production | Ohio Valley, USA    | 2006                   | Previous employee                  | Serum             | LC-MS                   | 1447                | NR (NR)           | (NR–NR)         | 74.9 (NR, NR)        | 0.5                        | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         |   |
| Wang et al. (2012)      | Fluorochemical production | China               | 2011                   | NR                                 | Serum             | LC-MS/MS                | 55                  | 2157.74 (1272.31) | (84.98–7737.13) | 1635.96 (NR, NR)     | 0.01*                      | 42.63 (33.33) | (5.23–165.69) | 33.46 (NR, NR)     | 0.01*                      | PFC chemical plant workers  |
| Lu et al. (2019)        | Fluorochemical production | China               | 2017                   | NR                                 | Plasma            | LC-MS/MS                | 40                  | 570.3 (136.6)     | (2–7214)        | 164.6 (NR, NR)       | 0                          | 3183 (753)    | (9.6–43 299)  | 909.3 (NR, NR)     | 0                          |   |
| Batzella et al. (2022)  | Fluorochemical production | Veneto, Italy       | 2020                   | Fluorochemical production facility | Serum             | LC-MS/MS                | 232                 | 624.74 (87.4)     | (0.35–13 033)   | 80.8 (14.88, 469.55) | 0.1                        | 15.62 (8.91)  | (0.35–343)    | 8.55 (4.95, 15.93) | 0.1                        | Former employees at a fluorochemical production facility  |
| Winqvist et al. (2013)  | Fluorochemical production | West Virginia, USA  | 2011                   | C8 Health Project                  | Serum             |                         | 1881                | 324.6 (NR)        | (NR–NR)         | 112.7 (55.9, NR)     | NR                         | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         | Worker cohort from C8 Health Project  |
| Woskie et al. (2012)    | Fluorochemical production | USA                 | 1972–2004              | All                                | Serum             | Multiple – see comments | 1308                | 2050 (NR)         | (7–59 400)      | 580 (NR, NR)         | NR                         | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |
| Woskie et al. (2012)    | Fluorochemical production | USA                 | 1972–2004              | Fine powder and granular PTFE      | Serum             | Multiple – see comments | 170                 | 5470 (NR)         | (90–59 400)     | 2880 (NR, NR)        | NR                         | NR (NR)       | (NR–NR)       | NR (NR, NR)        | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |

**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference             | Occupational group        | Geographic location | Sample collection year | Job, task, or subgroup description              | Biological matrix | Analytical method       | No. of participants | PFOA (ng/mL) |                 |                 |                            | PFOS (ng/mL)  |                  |                   |                            | Comments  |
|-----------------------|---------------------------|---------------------|------------------------|---|-------------------|-------------------------|---------------------|--------------|-----------------|-----------------|----------------------------|---------------|------------------|-------------------|----------------------------|---|
|                       |                           |                     |                        |   |                   |                         |                     | Mean (GM)    | Range           | Median (IQR)    | LOD (LOQ indicated with *) | Mean/GM       | Range            | Median (IQR)      | LOD (LOQ indicated with *) |   |
| Woskie et al. (2012)  | Fluorochemical production | USA                 | 1972–2004              | FEP/PFA   | Serum             | Multiple – see comments | 96                  | 2530 (NR)    | (130–14 040)    | 1690 (NR, NR)   | NR                         | NR (NR)       | (NR–NR)          | NR (NR, NR)       | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |
| Woskie et al. (2012)  | Fluorochemical production | USA                 | 1972–2004              | Non-PFOA job in PTFE and co-polymer production  | Serum             | Multiple – see comments | 480                 | 840 (NR)     | (8–14 580)      | 440 (NR, NR)    | NR                         | NR (NR)       | (NR–NR)          | NR (NR, NR)       | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |
| Woskie et al. (2012)  | Fluorochemical production | USA                 | 1972–2004              | Maintenance                                     | Serum             | Multiple – see comments | 200                 | 890 (NR)     | (60–6810)       | 500 (NR, NR)    | NR                         | NR (NR)       | (NR–NR)          | NR (NR, NR)       | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |
| Woskie et al. (2012)  | Fluorochemical production | USA                 | 1972–2004              | Non-PTFE/co-polymer production with no PFOA use | Serum             | Multiple – see comments | 463                 | 240 (NR)     | (7–4140)        | 160 (NR, NR)    | NR                         | NR (NR)       | (NR–NR)          | NR (NR, NR)       | NR                         | PFC chemical plant workers. Methods 1972–1981: whole blood, Wickbold torch; 1981–2003: whole blood, GC-ECD; 2003–2004: serum, LC-MS/MS. All results adjusted to serum equivalent. |
| Tanner et al. (2018)  | Multiple                  | New York, USA       | 2002                   | NR  | Serum             | LC-MS/MS                | 154                 | NR (8.1)     | (0.6–42.7)      | 8.1 (5.6, 11.8) | 0.5*                       | NR (34.3)     | (4.6–217)        | 32.7 (22.7, 49.1) | 0.5*                       | Hudson River Cohort. Occupations assigned by likelihood of exposure into none (55.8% of cohort), low (18.2%), moderate (26%), and high (0%).                                      |
| Clarity et al. (2020) | Office                    | California, USA     | 2015                   | NR  | Serum             | LC-MS/MS                | 79                  | NR (1.19)    | (NR–NR)         | NR (NR, NR)     | 0.02                       | NR (4.03)     | (NR–NR)          | NR (NR, NR)       | 0.02                       | Female population   |
| Fraser et al. (2012)  | Office                    | California, USA     | 2009                   | NR  | Serum             | LC-MS                   | 31                  | NR (3.7)     | (1.1–8.9)       | NR (NR, NR)     | 0.1                        | NR (11)       | (2.8–67)         | NR (NR, NR)       | 0.2                        |   |
| Wu et al. (2019)      | Retail                    | China               | 2017                   | NR  | Urine             | LC-MS/MS                | 73                  | 0.662 (NR)   | (0.2072–0.9067) | 0.6661 (NR, NR) | 0.324                      | 0.02 358 (NR) | (0.00073–0.1507) | 0.01225 (NR, NR)  | 0.1114                     | Retail clothing workers   |
| Freberg et al. (2010) | Skiwax technicians        | Norway              | 2008                   | NR  | Serum             | LC-MS                   | 13                  | NR (NR)      | (20–174)        | 50 (NR, NR)     | 0.05*                      | NR (NR)       | (11–91)          | 27 (NR, NR)       | 0.05*                      |   |
| Nilsson et al. (2010) | Skiwax technicians        | Sweden              | 2008                   | NR  | Whole blood       | ES-MS/MS                | 8                   | 140 (NR)     | (4.8–535)       | 112 (NR, NR)    | 0.13                       | NR (NR)       | (0.3–27)         | 12.2 (NR, NR)     | 0.042                      | Blood collected at multiple timepoints before and after ski seasons   |
| Nilsson et al. (2013) | Skiwax technicians        | Sweden              | 2007–2011              | NR  | Whole blood       | ESI-MS/MS               | 11                  | 130 (NR)     | (1.9–630)       | 110 (NR, NR)    | 0.13                       | 11 (NR)       | (0.28–27)        | 11 (NR, NR)       | 0.042                      | Blood collected at multiple timepoints before and after ski seasons   |

**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference                     | Occupational group                | Geographic location      | Sample collection year | Job, task, or subgroup description | Biological matrix | Analytical method | No. of participants | PFOA (ng/mL) |               |               |                            | PFOS (ng/mL) |               |               |                            | Comments   |
|-------------------------------|-----------------------------------|--------------------------|------------------------|------------------------------------|-------------------|-------------------|---------------------|--------------|---------------|---------------|----------------------------|--------------|---------------|---------------|----------------------------|--|
|                               |                                   |                          |                        |                                    |                   |                   |                     | Mean (GM)    | Range         | Median (IQR)  | LOD (LOQ indicated with *) | Mean/GM      | Range         | Median (IQR)  | LOD (LOQ indicated with *) |  |
| Zhang et al. (2011)           | Leather factory                   | China                    | 2009                   | NR                                 | Serum             | LC-MS             | 50                  | 6.93 (NR)    | (0.17–117.77) | 3.49 (NR, NR) | NR                         | 6.19 (NR)    | (0.05–63.06)  | 4.88 (NR, NR) | NR                         | Population from Wenzhou metropolis area, also called “Footwear Capital” of China. Samples also collected from infertile men and umbilical cords.   |
| Lu et al. (2014)              | Textile mill                      | Shandong province, China | 2012                   | NR                                 | Blood             | LC-ESI-MS/MS      | 20                  | 5.46 (NR)    | (2.35–10.92)  | NR (NR, NR)   | NR                         | 5.73 (NR)    | (1.34–14.75)  | (NR, NR)      | NR                         |  |
| Shi et al. (2016)             | Metal plating                     | Shandong province, China | 0                      | NR                                 | Urine             | LC                | 19                  | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | 3.25 (NR)    | (0.0004–34.4) | 1.56 (NR, NR) | NR                         | Process workers involved with chrome plating vats where fluorinated surfactants are used as mist suppressants.   |
| Shi et al. (2016)             | Metal plating                     | Shandong province, China | 0                      | NR                                 | Serum             | LC-MS             | 19                  | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | NR (NR)      | (2.4–1323)    | 40 (NR, NR)   | NR                         | Process workers involved with chrome plating vats where fluorinated surfactants are used as mist suppressants.   |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy  | 2004–2021              | Chemical plant-All                 | Serum             | LC-MS             | 252                 | NR (NR)      | (NR–19 920)   | 81 (NR, NR)   | 5–1*                       | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy  | 2004–2021              | Chemical plant-Plastomers 1        | Serum             | LC-MS             | 17                  | NR (NR)      | (NR–4790)     | 71 (NR, NR)   | 5–1*                       | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy  | 2004–2021              | Chemical plant-Plastomers 2        | Serum             | LC-MS             | 64                  | NR (NR)      | (NR–19 920)   | 557 (NR, NR)  | 5–1*                       | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy  | 2004–2021              | Chemical plant-Elastomers          | Serum             | LC-MS             | 44                  | NR (NR)      | (NR–8100)     | 21 (NR, NR)   | 5–1*                       | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy  | 2004–2021              | Chemical plant-Fluids              | Serum             | LC-MS             | 34                  | NR (NR)      | (NR–1530)     | 9 (NR, NR)    | 5–1*                       | NR (NR)      | (NR–NR)       | NR (NR, NR)   | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present  |

**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference                     | Occupational group                | Geographic location     | Sample collection year | Job, task, or subgroup description          | Biological matrix | Analytical method | No. of participants | PFOA (ng/mL) |           |              |                            | PFOS (ng/mL) |         |              |                            | Comments   |
|-------------------------------|-----------------------------------|-------------------------|------------------------|---|-------------------|-------------------|---------------------|--------------|-----------|--------------|----------------------------|--------------|---------|--------------|----------------------------|--|
|                               |                                   |                         |                        |   |                   |                   |                     | Mean (GM)    | Range     | Median (IQR) | LOD (LOQ indicated with *) | Mean/GM      | Range   | Median (IQR) | LOD (LOQ indicated with *) |  |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy | 2004–2021              | Chemical plant-Perfluoro Vinyl Ether (PFVE) | Serum             | LC-MS             | 19                  | NR (NR)      | (NR–130)  | 8 (NR, NR)   | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.<br>ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy | 2004–2021              | Chemical plant-Maintenance                  | Serum             | LC-MS             | 68                  | NR (NR)      | (NR–4670) | 65 (NR, NR)  | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.   |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Spinetta Marengo, Italy | 2004–2021              | Chemical plant-Mixed (non-exposed)          | Serum             | LC-MS             | 26                  | NR (NR)      | (NR–8830) | 35 (NR, NR)  | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.   |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Bollate, Italy          | 2008–2021              | Research centre-All                         | Serum             | LC-MS             | 58                  | NR (NR)      | (NR–2460) | < 5 (NR, NR) | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | Most research centre data collected 2018–2012. ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.                                      |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Bollate, Italy          | 2008–2021              | Research centre-Pilot                       | Serum             | LC-MS             | 22                  | NR (NR)      | (NR–2460) | < 5 (NR, NR) | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | Most research centre data collected 2018–2012. ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.                                      |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Bollate, Italy          | 2008–2021              | Research centre-Laboratories                | Serum             | LC-MS             | 10                  | NR (NR)      | (NR–19)   | < 5 (NR, NR) | 5–1*                       | NR (NR)      | (NR–NR) | NR (NR, NR)  | NR                         | Most research centre data collected 2018–2012. ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s-2013 (PFOA), 1996-present (ADV), and 2012-present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period.                                      |



**Table S1.15 Occupational exposure to PFOA and PFOS measured in biological matrices**

| Reference                     | Occupational group                | Geographic location | Sample collection year | Job, task, or subgroup description | Biological matrix | Analytical method | No. of participants | PFOA (ng/mL) |              |                 |                            | PFOS (ng/mL) |             |               |                            | Comments  |
|-------------------------------|-----------------------------------|---------------------|------------------------|------------------------------------|-------------------|-------------------|---------------------|--------------|--------------|-----------------|----------------------------|--------------|-------------|---------------|----------------------------|---|
|                               |                                   |                     |                        |                                    |                   |                   |                     | Mean (GM)    | Range        | Median (IQR)    | LOD (LOQ indicated with *) | Mean/GM      | Range       | Median (IQR)  | LOD (LOQ indicated with *) |   |
| Fustinoni and Consonni (2023) | Perfluoroalkyl polymer production | Bollate, Italy      | 2008–2021              | Research centre-Mix (non-exposed)  | Serum             | LC-MS             | 46                  | NR (NR)      | (NR–150)     | < 5 (NR, NR)    | 5–1*                       | NR (NR)      | (NR–NR)     | NR (NR, NR)   | NR                         | Most research centre data collected 2018–2021. ADV (a polymerization reaction) and cC <sub>6</sub> O <sub>4</sub> also measured in serum. Exposure occurred from 1960s–2013 (PFOA), 1996–present (ADV), and 2012–present (cC <sub>6</sub> O <sub>4</sub> ). Decreasing trends observed over study period. |
| Göen et al. (2023)            | Welders                           | Europe              | 2018–2019              | NR                                 | Plasma            | TQMS              | 43                  | NR (NR)      | (0.34–5.36)  | 1.29 (NR, 4.72) | 0.02*                      | NR (NR)      | (1.01–1513) | 4.97 (NR, NR) | 0.03*                      | HBM4EU chromate study   |
| Göen et al. (2023)            | Chrome plating workers            | Europe              | 2018–2019              | NR                                 | Plasma            | TQMS              | 52                  | NR (NR)      | (< 0.1–3.38) | 1.45 (NR, 3.07) | 0.02*                      | NR (NR)      | (0.89–789)  | 4.83 (NR, NR) | 0.03*                      | HBM4EU chromate study   |

ADV, a polymerization reaction mass of perfluoropolyether carboxylic acids containing multiple isomers (CAS No. 330809-92-2); AFFF, aqueous film-forming foam; APFO, ammonium perfluorooctanoate; C8, a synonym for PFOA; cC<sub>6</sub>O<sub>4</sub>, acetic acid, 2,2-difluoro-2-[[2,2,4,5-tetrafluoro-5-(trifluoromethoxy)-1,3-dioxolan-4-yl]oxy]-, ammonium salt (1:1) CAS No. 1190931-27-1; ECD, electron capture detector; ESI, electrospray ionization; FEP, fluorinated ethylene propylene; GC, gas chromatography; GM, geometric mean; HBM4EU, Human Biomonitoring for Europe; IQR, interquartile range; LC, liquid chromatography; LOD, limit of detection; LOQ, limit of quantification; MS, mass spectrometry; MS/MS, tandem mass spectrometry; NA, not applicable; NR, not reported; NW, north-west; PFA, perfluoroalkoxy; PFAS, per- and polyfluoroalkyl substances; PFC, perfluorinated compound; PFOA, perfluorooctanoic acid; PFOS, perfluorooctanesulfonic acid; PTFE, polytetrafluoroethylene; RCT, randomized controlled trial; SE, south-east; SW, south-west; TQMS, triple quadrupole mass spectrometry; USA, United States of America.

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