

## Serum Biomarkers of Exposure to Perfluoroalkyl Substances in Relation to Serum Testosterone and Measures of Thyroid Function among Adults and Adolescents from NHANES 2011–2012

**Table S1.** Percent change (95% CI) in serum hormone concentration associated with a doubling (100% increase) in serum PFAS concentration among males from NHANES 2011–2012 (unadjusted results).

| Hormone    | PFAS  | 12 to <20 years old<br>( <i>n</i> = 158) <sup>a</sup> | 20 to <40 years old<br>( <i>n</i> = 268) <sup>a</sup> | 40 to <60 years old<br>( <i>n</i> = 218) <sup>a</sup> | 60 to 80 years old<br>( <i>n</i> = 213) <sup>a</sup> |
|------------|-------|---|---|---|--|
| T (total)  | PFOA  | 33.4 (1.6, 75.2) **                                   | -0.1 (-4.9, 5.1)                                      | -1.5 (-8.1, 5.5)                                      | 7.2 (-1.8, 17.2)                                     |
|            | PFOS  | 19.6 (-0.2, 43.3) *                                   | -1.0 (-5.2, 3.4)                                      | -1.1 (-6.0, 4.0)                                      | 4.8 (-1.9, 12.0)                                     |
|            | PFHxS | 1.4 (-10.9, 15.4)                                     | -0.9 (-4.5, 2.9)                                      | -3.8 (-8.6, 1.2)                                      | 3.1 (-3.9, 10.5)                                     |
|            | PFNA  | 10.4 (-8.9, 33.7)                                     | 1.1 (-4.5, 6.9)                                       | 1.6 (-4.0, 7.5)                                       | 8.7 (-0.8, 19.1)*                                    |
| T3 (free)  | PFOA  | -0.9 (-4.1, 2.4)                                      | -0.5 (-1.7, 0.6)                                      | 0.0 (-1.5, 1.6)                                       | -0.1 (-1.6, 1.4)                                     |
|            | PFOS  | -2.1 (-4.3, -0.0) *                                   | -0.5 (-1.5, 0.5)                                      | 0.5 (-0.7, 1.6)                                       | -0.8 (-1.9, 0.3)                                     |
|            | PFHxS | -0.2 (-1.7, 1.4)                                      | -0.2 (-1.1, 0.6)                                      | -0.5 (-1.6, 0.7)                                      | -1.0 (-2.2, 0.1)*                                    |
|            | PFNA  | -1.2 (-3.5, 1.1)                                      | -0.1 (-1.4, 1.2)                                      | 0.8 (-0.5, 2.1)                                       | 0.3 (-1.3, 1.9)                                      |
| T3 (total) | PFOA  | -5.3 (-10.1, -0.2) **                                 | -1.3 (-3.2, 0.7)                                      | 0.6 (-2.2, 3.4)                                       | 1.0 (-1.8, 3.9)                                      |
|            | PFOS  | -4.8 (-8.0, -1.5) **                                  | -0.8 (-2.5, 0.9)                                      | 0.2 (-1.9, 2.3)                                       | -0.9 (-3.0, 1.2)                                     |
|            | PFHxS | -0.3 (-2.7, 2.2)                                      | -0.0 (-1.5, 1.5)                                      | 1.1 (-1.0, 3.2)                                       | -1.8 (-4.0, 0.4)                                     |
|            | PFNA  | -3.5 (-6.9, 0.1) *                                    | -0.4 (-2.7, 1.9)                                      | 0.4 (-1.8, 2.8)                                       | 1.2 (-1.7, 4.2)                                      |
| T4 (free)  | PFOA  | -0.8 (-4.9, 3.3)                                      | -0.1 (-2.0, 1.8)                                      | -2.7 (-5.3, 0.1) *                                    | 0.5 (-1.7, 2.8)                                      |
|            | PFOS  | 0.8 (-1.9, 3.6)                                       | -0.8 (-2.4, 0.8)                                      | 0.4 (-1.7, 2.5)                                       | 0.8 (-0.9, 2.5)                                      |
|            | PFHxS | -1.4 (-3.3, 0.5)                                      | -1.1 (-2.5, 0.3)                                      | -0.1 (-2.1, 2.0)                                      | 0.5 (-1.3, 2.3)                                      |
|            | PFNA  | 2.7 (-0.2, 5.6) *                                     | 0.6 (-1.5, 2.8)                                       | -0.1 (-2.4, 2.3)                                      | 0.8 (-1.5, 3.2)                                      |
| T4 (total) | PFOA  | -3.3 (-7.8, 1.6)                                      | -1.5 (-3.6, 0.8)                                      | -3.5 (-6.5, -0.4) **                                  | -1.1 (-3.8, 1.8)                                     |
|            | PFOS  | -1.4 (-4.6, 1.8)                                      | -1.9 (-3.8, -0.0) *                                   | -0.8 (-3.2, 1.6)                                      | -1.1 (-3.2, 1.0)                                     |
|            | PFHxS | -2.1 (-4.3, 0.1) *                                    | -0.7 (-2.4, 1.0)                                      | -0.9 (-3.2, 1.5)                                      | -1.9 (-4.0, 0.3) *                                   |
|            | PFNA  | 0.6 (-2.7, 4.1)                                       | -0.6 (-3.0, 2.0)                                      | -1.9 (-4.5, 0.7)                                      | -0.6 (-3.5, 2.4)                                     |
| TSH        | PFOA  | 8.4 (-7.7, 27.4)                                      | 0.7 (-5.9, 7.7)                                       | 0.3 (-9.7, 11.4)                                      | -2.1 (-11.3, 8.0)                                    |
|            | PFOS  | 15.1 (3.7, 27.8) **                                   | -3.1 (-8.6, 2.7)                                      | -2.0 (-9.4, 5.9)                                      | -2.8 (-9.7, 4.7)                                     |
|            | PFHxS | 8.7 (0.9, 17.1) **                                    | -0.1 (-5.1, 5.1)                                      | 0.2 (-7.4, 8.4)                                       | -3.9 (-11.0, 3.9)                                    |
|            | PFNA  | 16.0 (4.0, 29.5) **                                   | -1.0 (-8.3, 6.8)                                      | 0.5 (-7.9, 9.6)                                       | -4.7 (-14.0, 5.5)                                    |

\* 0.05 ≤ *p* < 0.10. \*\* *p* < 0.05.

**Table S2.** Percent change (95% CI) in serum hormone concentration associated with a doubling (100% increase) in serum PFAS concentration among females from NHANES 2011–2012 (unadjusted results).

| Hormone    | PFAS  | 12 to <20 years old<br>(n = 145) <sup>a</sup> | 20 to <40 years old<br>(n = 257) <sup>a</sup> | 40 to <60 years old<br>(n = 224) <sup>a</sup> | 60 to 80 years old<br>(n = 199) <sup>a</sup> |
|------------|-------|---|---|---|--|
| T (total)  | PFOA  | -11.8 (-22.2, -0.0) *                         | 3.8 (-3.9, 12.0)                              | -5.0 (-12.7, 3.4)                             | 4.3 (-5.7, 15.4)                             |
|            | PFOS  | -7.2 (-14.6, 0.9) *                           | 1.9 (-4.5, 8.6)                               | -2.9 (-8.9, 3.5)                              | 6.9 (-0.8, 15.1) *                           |
|            | PFHxS | -6.5 (-12.2, -0.4) **                         | -2.8 (-8.2, 2.9)                              | -1.9 (-8.0, 4.6)                              | 1.2 (-6.9, 9.9)                              |
|            | PFNA  | -10.5 (-19.2, -0.8) **                        | 5.6 (-2.3, 14.1)                              | -6.3 (-14.1, 2.2)                             | 5.4 (-3.3, 14.8)                             |
| T3 (free)  | PFOA  | 1.5 (-2.1, 5.2)                               | 0.2 (-1.3, 1.7)                               | -0.1 (-1.6, 1.3)                              | 1.6 (0.0, 3.1) *                             |
|            | PFOS  | -1.5 (-3.8, 0.9)                              | 0.2 (-1.1, 1.4)                               | -0.5 (-1.6, 0.6)                              | 0.7 (-0.4, 1.9)                              |
|            | PFHxS | -0.6 (-2.4, 1.2)                              | 0.5 (-0.6, 1.6)                               | -0.1 (-1.2, 1.0)                              | 0.8 (-0.4, 2.1)                              |
|            | PFNA  | -1.4 (-4.3, 1.5)                              | 0.6 (-0.9, 2.1)                               | 0.6 (-0.9, 2.1)                               | 0.9 (-0.4, 2.2)                              |
| T3 (total) | PFOA  | 0.2 (-4.3, 5.0)                               | -0.8 (-3.4, 1.8)                              | -1.3 (-4.0, 1.4)                              | 3.2 (0.6, 6.0) **                            |
|            | PFOS  | -2.8 (-5.7, 0.2) *                            | -0.6 (-2.7, 1.7)                              | -1.6 (-3.6, 0.4)                              | 0.6 (-1.3, 2.6)                              |
|            | PFHxS | -0.9 (-3.2, 1.4)                              | 0.8 (-1.2, 2.7)                               | 0.2 (-1.8, 2.3)                               | 1.9 (-0.3, 4.1) *                            |
|            | PFNA  | -2.2 (-5.9, 1.5)                              | -0.8 (-3.4, 1.9)                              | -1.9 (-4.6, 0.9)                              | 1.9 (-0.4, 4.2)                              |
| T4 (free)  | PFOA  | 1.4 (-2.7, 5.7)                               | 1.9 (-0.1, 3.9) *                             | 1.8 (-0.6, 4.2)                               | -2.4 (-4.9, 0.3) *                           |
|            | PFOS  | -0.3 (-3.0, 2.5)                              | 2.0 (0.4, 3.7) **                             | 1.4 (-0.3, 3.3)                               | -0.8 (-2.7, 1.2)                             |
|            | PFHxS | -0.3 (-2.4, 1.8)                              | 1.0 (-0.5, 2.5)                               | 0.6 (-1.2, 2.4)                               | -2.0 (-4.1, 0.2) *                           |
|            | PFNA  | -2.2 (-5.5, 1.2)                              | 2.5 (0.5, 4.5) **                             | 3.0 (0.6, 5.5) **                             | -2.4 (-4.6, -0.1) **                         |
| T4 (total) | PFOA  | 3.0 (-1.3, 7.5)                               | -0.8 (-3.3, 1.8)                              | 0.3 (-2.5, 3.2)                               | -1.1 (-3.7, 1.5)                             |
|            | PFOS  | -0.2 (-3.1, 2.7)                              | -0.7 (-2.9, 1.5)                              | -0.4 (-2.5, 1.8)                              | -0.0 (-1.9, 1.9)                             |
|            | PFHxS | -0.4 (-2.6, 1.8)                              | -0.9 (-2.8, 1.0)                              | 0.5 (-1.6, 2.7)                               | -0.8 (-2.9, 1.3)                             |
|            | PFNA  | -3.3 (-6.7, 0.1) *                            | 0.3 (-2.3, 3.0)                               | 0.5 (-2.4, 3.5)                               | -0.5 (-2.7, 1.8)                             |
| TSH        | PFOA  | -14.7 (-26.6, -0.9) **                        | 0.6 (-7.6, 9.5)                               | 4.7 (-4.8, 15.1)                              | 5.6 (-5.6, 18.2)                             |
|            | PFOS  | -6.5 (-15.5, 3.4)                             | -1.3 (-8.1, 6.0)                              | 0.9 (-6.0, 8.4)                               | -0.1 (-8.1, 8.6)                             |
|            | PFHxS | -3.0 (-10.2, 4.7)                             | 0.3 (-5.8, 6.8)                               | 6.3 (-1.0, 14.1) *                            | -0.3 (-9.2, 9.3)                             |
|            | PFNA  | 3.0 (-9.1, 16.8)                              | -3.4 (-11.4, 5.3)                             | 0.1 (-9.2, 10.3)                              | 1.9 (-7.5, 12.1)                             |

\*  $0.05 \leq p < 0.10$ . \*\*  $p < 0.05$ .

**Table S3.** Percent change (95% CI) in serum hormone concentration associated with a doubling (100% increase) in serum PFAS concentration among adult males from NHANES 2011–2012 (adjusted results).

| <b>Hormone</b> | <b>PFAS</b> | <b>20 to &lt;50 years old (n = 373) <sup>a</sup></b> | <b>50 to 80 years old (n = 326) <sup>a</sup></b> |
|----------------|-------------|--|--|
| T (total)      | PFOA        | -1.1 (-5.1, 3.0)                                     | 5.4 (-1.5, 12.8)                                 |
|                | PFOS        | -2.2 (-5.5, 1.2)                                     | 3.6 (-1.6, 8.9)                                  |
|                | PFHxS       | -2.3 (-5.3, 0.8)                                     | 1.7 (-3.5, 7.2)                                  |
|                | PFNA        | 0.7 (-3.3, 4.9)                                      | 3.6 (-3.4, 11.1)                                 |
| T3 (free)      | PFOA        | -0.1 (-1.1, 0.9)                                     | -0.0 (-1.2, 1.2)                                 |
|                | PFOS        | 0.2 (-0.6, 1.1)                                      | -0.2 (-1.1, 0.7)                                 |
|                | PFHxS       | -0.2 (-0.9, 0.6)                                     | -0.6 (-1.5, 0.3)                                 |
|                | PFNA        | 0.6 (-0.4, 1.6)                                      | 0.1 (-1.1, 1.4)                                  |
| T3 (total)     | PFOA        | -0.6 (-2.3, 1.1)                                     | 1.3 (-1.0, 3.7)                                  |
|                | PFOS        | -0.0 (-1.4, 1.4)                                     | -0.2 (-1.9, 1.6)                                 |
|                | PFHxS       | 0.4 (-0.9, 1.7)                                      | -0.7 (-2.5, 1.1)                                 |
|                | PFNA        | 0.4 (-1.3, 2.1)                                      | 0.5 (-1.9, 2.9)                                  |
| T4 (free)      | PFOA        | -0.4 (-2.0, 1.2)                                     | -0.3 (-2.4, 1.8)                                 |
|                | PFOS        | -0.3 (-1.7, 1.1)                                     | 0.6 (-1.0, 2.2)                                  |
|                | PFHxS       | -0.6 (-1.9, 0.7)                                     | 0.5 (-1.1, 2.2)                                  |
|                | PFNA        | 0.4 (-1.2, 2.1)                                      | -0.4 (-2.5, 1.8)                                 |
| T4 (total)     | PFOA        | -1.0 (-3.0, 1.0)                                     | -1.5 (-4.0, 0.9)                                 |
|                | PFOS        | -0.9 (-2.6, 0.7)                                     | -0.8 (-2.6, 1.1)                                 |
|                | PFHxS       | -0.1 (-1.6, 1.5)                                     | -1.5 (-3.4, 0.4)                                 |
|                | PFNA        | -0.4 (-2.3, 1.7)                                     | -1.4 (-3.9, 1.1)                                 |
| TSH            | PFOA        | 0.9 (-5.0, 7.1)                                      | -0.0 (-8.2, 9.0)                                 |
|                | PFOS        | -1.7 (-6.6, 3.4)                                     | -1.2 (-7.4, 5.3)                                 |
|                | PFHxS       | -0.0 (-4.6, 4.7)                                     | -1.0 (-7.4, 5.9)                                 |
|                | PFNA        | 0.4 (-5.4, 6.6)                                      | 1.5 (-7.1, 10.9)                                 |

<sup>a</sup> Adjusted for age (continuous), BMI (continuous), PIR (continuous), serum cotinine (continuous), and race/ethnicity (categorical).

**Table S4.** Percent change (95% CI) in serum hormone concentration associated with a doubling (100% increase) in serum PFAS concentration among adult females from NHANES 2011–2012 (adjusted results).

| Hormone    | PFAS  | 20 to <50 years old (n = 372) <sup>a</sup> | 50 to 80 years old (n = 308) <sup>a</sup> |
|------------|-------|--|---|
| T (total)  | PFOA  | 1.0 (−5.2, 7.6)                            | −1.9 (−9.7, 6.6)                          |
|            | PFOS  | 0.8 (−4.2, 6.0)                            | 5.2 (−1.2, 12.0)                          |
|            | PFHxS | −2.8 (−7.3, 2.0)                           | −2.8 (−8.9, 3.8)                          |
|            | PFNA  | 3.5 (−2.8, 10.4)                           | 1.8 (−5.6, 9.8)                           |
| T3 (free)  | PFOA  | 0.3 (−0.9, 1.5)                            | 1.4 (0.1, 2.7) **                         |
|            | PFOS  | 0.1 (−0.8, 1.1)                            | 0.7 (−0.3, 1.7)                           |
|            | PFHxS | 0.4 (−0.5, 1.3)                            | 0.6 (−0.4, 1.7)                           |
|            | PFNA  | 0.7 (−0.5, 1.9)                            | 1.1 (−0.1, 2.4) *                         |
| T3 (total) | PFOA  | −0.5 (−2.5, 1.7)                           | 2.6 (0.2, 5.0) **                         |
|            | PFOS  | −0.1 (−1.8, 1.6)                           | 0.3 (−1.5, 2.1)                           |
|            | PFHxS | 0.7 (−0.9, 2.3)                            | 2.0 (0.2, 3.9) **                         |
|            | PFNA  | −0.4 (−2.5, 1.7)                           | 1.1 (−1.1, 3.3)                           |
| T4 (free)  | PFOA  | 1.9 (0.2, 3.7) **                          | −1.3 (−3.4, 0.9)                          |
|            | PFOS  | 2.0 (0.6, 3.4) **                          | −0.5 (−2.1, 1.1)                          |
|            | PFHxS | 1.1 (−0.2, 2.5)                            | −1.2 (−2.9, 0.5)                          |
|            | PFNA  | 2.5 (0.8, 4.3) **                          | −1.1 (−3.0, 0.9)                          |
| T4 (total) | PFOA  | 0.7 (−1.4, 2.9)                            | −1.2 (−3.5, 1.3)                          |
|            | PFOS  | −0.1 (−1.8, 1.6)                           | −0.7 (−2.5, 1.1)                          |
|            | PFHxS | −0.0 (−1.6, 1.6)                           | −0.5 (−2.3, 1.4)                          |
|            | PFNA  | 0.8 (−1.3, 3.0)                            | −0.8 (−2.9, 1.4)                          |
| TSH        | PFOA  | 1.0 (−5.5, 8.1)                            | 3.2 (−6.3, 13.6)                          |
|            | PFOS  | −1.1 (−6.2, 4.4)                           | −0.3 (−7.4, 7.2)                          |
|            | PFHxS | 0.5 (−4.4, 5.8)                            | 1.2 (−6.2, 9.1)                           |
|            | PFNA  | −3.7 (−9.9, 3.1)                           | 4.2 (−4.5, 13.7)                          |

<sup>a</sup> Adjusted for age (continuous), BMI (continuous), PIR (continuous), serum cotinine (continuous), and race/ethnicity (categorical). \*  $0.05 \leq p < 0.10$ . \*\*  $p < 0.05$ .