## Biochemical analytical plan in children and adults: performing laboratories, reference levels, reporting ranges, clinical guidelines, and critical values.

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **NHANES 1****(µg/L)****2013 - 2014** |
| ***Children and Adults*** |
| ***NCEH/Division of Laboratory Sciences\*****Contact: Dr. Antonia Calafat* | *Per- and Poly-fluoroalkyl Substances (PFAS)* | Yes | Serum | 1 ml (for all PFAS); 1 ml reserve (for future PFAS analyses) | **Age Group (years):** | **50th to 95th %** |
| perfluorooctanoic acid (PFOA)‡ | 3-5:6-11:12-19:20+:  | 1.80 – 5.581.94 – 3.841.67 – 3.472.07 – 5.60 |
| n-PFOA - linear isomer | 3-5:6-11:12-19:20+:  | 1.72 – 5.321.84 – 3.771.60 – 3.402.00 – 5.40 |
| Sb-PFOA - serum branched isomer | 3-5:6-11:12-19:20+: | < LOD – 0.280< LOD – 0.230< LOD – 0.200< LOD – 0.200 |
| perfluorooctane sulfonic acid, (PFOS)‡ | 3-5:6-11:12-19:20+:  | 3.41 – 8.824.02 – 12.43.60 – 9.305.60 – 19.5 |
| n-PFOS – linear isomer | 3-5:6-11:12-19:20+: | 2.11 – 6.192.65 – 8.412.70 – 7.103.70 – 15.1 |
| Sm-PFOS – serum branched | 3-5:6-11:12-19:20+: | 1.00 – 3.601.41 – 4.251.00 – 2.301.60 – 5.30 |

Limit of detection (LOD, see Data Analysis section) for Survey year 13-14 is 0.1. < LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample.

1 CDC. 2018. 2013-2014 NHANES 50th to 95th percentiles among children 12-19 years and adults 20+ years old from the Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, March 2018. Accessed April 13, 2018 at (<https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume1_Mar2018.pdf>).

‡ See Calculation of PFOS and PFOA as the Sum of Isomers for additional information in March 2018 Updated Tables.

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **NHANES 1** **(µg/L)****2013 - 2014** |
| ***Children and Adults*** |
| ***NCEH/Division of Laboratory Sciences\*****Contact: Dr. Antonia Calafat* | *Per- and Poly-fluoroalkyl Substances (PFAS) (continued)* | Yes | Serum | 1 ml (for all PFAS); 1 ml reserve (for future PFAS analyses) | **Age Group (years):** | **50th to 95th %** |
| perfluorohexane sulfonic acid (PFHxS) | 3-5:6-11:12-19:20+:  | 0.740 – 1.620.850 – 4.141.10 – 6.301.40 – 5.50 |
| perfluorooctane sulfonamide (PFOSA) | 3-5:6-11:12-19:20+:  | < LOD – 0.110< LOD - < LODn/a ‡n/a ‡ |
| 2-(N-methyl-perfluorooctane sulfonamido) acetic acid (Me-PFOSAA) | 3-5:6-11:12-19:20+:  | 0.110 – 1.020.110 – 0.9400.100 – 0.600< LOD – 0.600 |
| 2-(N-ethyl-perfluorooctane sulfonamido) acetic acid (Et-PFOSAA) | 3-5:6-11:12-19:20+:  | < LOD - < LOD< LOD - < LODn/a ‡n/a ‡ |
| perfluorobutane sulfonic acid (PFBS)  | 3-5:6-11:12-19:20+:  | < LOD - < LOD< LOD – 0.130< LOD - < LOD< LOD - < LOD |
| perfluoroheptanoic acid (PFHpA) | 3-5:6-11:12-19:20+:  | < LOD – 0.310< LOD – 0.170< LOD – 0.200< LOD – 0.100 |

Limit of detection (LOD, see Data Analysis section) for Survey year 13-14 is 0.1. < LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. ‡ Not measured after Survey Years 2011-2012.

1 CDC. 2018. 2013-2014 NHANES 50th to 95th percentiles among children 12-19 years and adults 20+ years old from the Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, March 2018. Accessed April 13, 2018 at (<https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume1_Mar2018.pdf>).

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **NHANES 1** **(µg/L)****2013 - 2014** |
| ***Children and Adults*** |
| ***NCEH/Division of Laboratory Sciences\*****Contact: Dr. Antonia Calafat* | *Per- and Poly-fluoroalkyl Substances (PFAS) (continued)* | Yes | Serum | 1 ml (for all PFAS); 1 ml reserve (for future PFAS analyses) | **Age Group (years):** | **50th to 95th %** |
| perfluorononanoic acid (PFNA)  | 3-5:6-11:12-19:20+:  | 0.620 – 3.490.750 – 3.190.500 – 2.000.700 – 2.00 |
| perfluorodecanoic acid (PFDA)  | 3-5:6-11:12-19:20+:  | 0.100 – 0.370< LOD – 0.3500.100 – 0.4000.193 – 0.800 |
| perfluoroundecanoic acid (PFUnDA)  | 3-5:6-11:12-19:20+:  | < LOD – 0.370< LOD – 0.250< LOD – 0.200< LOD – 0.500 |
| perfluorododecanoic acid (PFDoA)  | 3-5:6-11:12-19:20+:  | < LOD - < LOD< LOD - < LOD< LOD – 0.200< LOD – 0.200 |
| **Laboratory and Contact** | **Proposed Biospecimen Bank for Future Analytes** | **\* CLIA Cert.** | **Matrix** | **Volume** | **NHANES TBD** **(µg/L)****20xx – 20xx** |
| ***Children and Adults*** |
| ***NCEH/Division of Laboratory Sciences\*****Contact: Dr. Antonia Calafat* | *Per- and Poly-fluoroalkyl Substances (PFAS)* | Yes | Spot Urine (morning void) | 1 ml (for PFAS);15 ml for creatinine/or specific gravity)  | **Age Group:** | **50th to 95th %** |
| To be determined (TBD) when analytical methods are developed(Including but not limited to the following 18 analytes: PFOA [n-PFOA;, Sb-PFOA], PFOA [n-PFOS, Sm-PFOS], PFHxS, PFBS, PFHpA, PFNA, PFDA, PFUnDA, PFPrS, PFHpS, PFBA, PFPeA, PFHxA, HFPO-DA (GenX), DONA, 9Cl-PF3ONS) | 3-5:6-11:12-19:20+:  | TBDTBDTBDTBD |
| Creatinine (for urinary creatinine correction; may be contracted) | TBD |

Limit of detection (LOD, see Data Analysis section) for Survey year 13-14 is 0.1. < LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. ‡ Not measured after Survey Years 2011-2012.

1 CDC. 2018. 2013-2014 NHANES 50th to 95th percentiles among children 12-19 years and adults 20+ years old from the Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, March 2018. Accessed April 13, 2018 at (<https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume1_Mar2018.pdf>).

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **Reportable Range, Guidelines,****Critical Values***Reference ranges will be updated when commercial lab is selected.* |
| ***Children and Adults*** |
| ***Commercial Laboratory (to be determined)\*****Contact:*  | *Lipids* | Yes | Serum | 0.5 ml (for all) |  |
| Total cholesterol, fasting | Coronary Heart Disease Risk (CHD)[[1]](#footnote-1)Adult, 18+ years:Desirable: <200 mg/dL Borderline High: 200-239 mg/dLHigh: ≥240 mg/dLChild, 2-17 years:Acceptable: <170 mg/dLBorderline high: 170-199 mg/dLHigh: ≥200 mg/dL |
| Triglycerides, fasting | CHD Risk1Adult, 18+ years:Normal: <150 mg/dLBorderline High: 150-199 mg/dLHigh: 200-499 mg/dLVery High: ≥500 mg/dL**Critical Value: >1,000 mg/dL**Child, 2-9 years:Acceptable: <75 mg/dLBorderline high: 75-99 mg/dLHigh: ≥100 mg/dLChild, 10-17 years:Acceptable: <90 mg/dLBorderline high: 90-129 mg/dLHigh: > or =130 mg/dL |
| Low Density Lipoprotein (LDL), fasting | CHD Risk1Adult, 18+ years:Desirable: <100 mg/dLAbove Desirable: 100-129 mg/dLBorderline high: 130-159 mg/dLHigh: 160-189 mg/dLVery high: ≥190 mg/dLChild, 2-17 years:Acceptable: <110 mg/dLBorderline high: 110-129 mg/dLHigh: ≥130 mg/dL |
| High Density Lipoprotein (HDL), fasting | CHD Risk1Adult, 18+ years:Males: ≥40 mg/dLFemales: ≥50 mg/dLChild, 2-17 years:Low: <40 mg/dLBorderline low: 40-45 mg/dLAcceptable: > 45 mg/dL |

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **Reportable Range, Guidelines,****Critical Values** *Reference ranges will be updated when commercial lab is selected.* |
| ***Children and Adults*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Uric Acid* | Yes | Serum | 1 ml | Males[[2]](#footnote-2)≤ 8.0 mg/dLFemales≤ 6.1 mg/dL |
| *Creatinine (to estimate glomerular filtration rate [eGFR])* | Males[[3]](#footnote-3)1-2 years: 0.1-0.4 mg/dL3-4 years: 0.1-0.5 mg/dL5-9 years: 0.2-0.6 mg/dL10-11 years: 0.3-0.7 mg/dL12-13 years: 0.4-0.8 mg/dL14-15 years: 0.5-0.9 mg/dL> or =16 years: 0.8-1.3 mg/dLReference values have not been established for patients that are <12 months of age. Females1-3 years: 0.1-0.4 mg/dL4-5 years: 0.2-0.5 mg/dL6-8 years: 0.3-0.6 mg/dL9-15 years: 0.4-0.7 mg/dL> or =16 years: 0.6-1.1 mg/dLReference values have not been established for patients that are <12 months of age. ESTIMATED GFR>60 mL/min/BSA**Note:** eGFR results will not be calculated for patients <18 or >70 years old. |
| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **Reportable Range, Guidelines,****Critical Values***Reference ranges will be updated when commercial lab is selected.* |
| ***Children and Adults*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Thyroid Hormones* | Yes | Serum | 0.5 ml |  |
| Thyroid Stimulating Hormone (TSH) | 0.30-3.0 mIU/L [[4]](#footnote-4)  |
| Free Total Thyroxine (Free T4) | 0.8-2.0 ng/dL  |
| Total Thyroxine (TT4) | 4.5-12.5 µg/dL  |
| Total Triiodothyronine (TT3) | 80-180 ng/dL  |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Liver Tests* | Yes | Serum | 0.5 ml standard tests; 1 ml CK18  |  |
| Alanine transaminase (ALT) | 15-65 U/L [[5]](#footnote-5) |
| Aspartate transaminase (AST) | 5-40 U/L  |
| Alkaline phosphatase (ALP) | Female: 50-136 U/L;Male: 40-136 U/L  |
| Gamma-glutamyltransferase (GGT) | Female 5-55 U/L;Male 5-85 U/L  |
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| *Albumin (Alb)* | 3.4-5.0 g/dL **Critical Value: <1.5 g/dL** **Critical Value: >7.9 g/dL**  |
| *Total bilirubin (TBIL)* | 0.0 – 1.0 mg/dL **Critical Value: >12.9 mg/dL**  |
| *Direct bilirubin (Conjugated Bilirubin)* | 0.0-0.3 mg/dL  |
|  |  |
| *Non-alcoholic fatty liver disease (NAFLD)/steatohepatitis* |  |
| Cytokeratin 18 M30 (CK-18 M30)Cytokeratin 18 M65 (CK-18 M65) | No evident liver disease: M30 <200 U/L and M65 <300 U/LTASH: M30<200 U/L and M65 >300 U/LOther liver disease: M30: >200 U/L |
| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **Reportable Range, Guidelines,** **Critical Values***Reference ranges will be updated when commercial lab is selected.* |
| ***Children and Adults*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Sex Hormones* | Yes | Serum | 1 ml |  |
| Testosterone | Males[[6]](#footnote-6)         4-9 years: <7-20 ng/dL10-11 years: <7-130 ng/dL12-13 years: <7-800 ng/dL14 years: <7-1,200 ng/dL15-16 years: 100-1,200 ng/dL17-18 years: 300-1,200 ng/dL≥19 years: 240-950 ng/dL       Females            4-9 years: <7-20 ng/dL10-11 years: <7-44 ng/dL12-16 years: <7-75 ng/dL17-18 years: 20-75 ng/dL≥19 years: 8-60 ng/dL |
| Estradiol | CHILDREN[[7]](#footnote-7)Males

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| **Tanner Stages** | **Reference Range** |
| Stage I (>14 days and prepubertal) | <LOD-13 pg/mL |
| Stage II | <LOD-16 pg/mL |
| Stage III | <LOD-26 pg/mL |
| Stage IV | <LOD-38 pg/mL |
| Stage V | 10-40 pg/mL |

Females

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| **Tanner Stages** | **Mean Age** | **Reference Range** |
| Stage I (>14 days and prepubertal) | 7.1 years | Undetectable-20 pg/mL |
| Stage II | 10.5 years | Undetectable-24 pg/mL |
| Stage III | 11.6 years | Undetectable-60 pg/mL |
| Stage IV | 12.3 years | 15-85 pg/mL |
| Stage V | 14.5 years | 15-350 pg/mL\*\* |

ADULTSMales: 10-40 pg/mLFemalesPremenopausal: 15-350 pg/mL\*\*Postmenopausal: <10 pg/mL\*\*E2 levels vary widely through the menstrual cycle. |
| Sex hormone-binding globulin (SHBG) | CHILDREN[[8]](#footnote-8)Males

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| Tanner Stages | Reference Range |
| Stage I | 31-167 nmol/L |
| Stage II | 49-179 nmol/L |
| Stage III | 5.8-182 nmol/L |
| Stage IV | 14-98 nmol/L |
| Stage V | 10-57 nmol/L |

Females

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| Tanner Stages | Reference Range |
| Stage I | 43-197 nmol/L |
| Stage II | 7.7-119 nmol/L |
| Stage III | 31-191 nmol/L |
| Stage IV | 31-166 nmol/L |
| Stage V | 18-144 nmol/L |

ADULTS           Males: 10-57 nmol/LFemales (non-pregnant): 18-144 nmol/L |
| Follicle stimulating hormone (FSH) | Males[[9]](#footnote-9)4-6 years: < or =6.7 IU/L7-8 years: < or =4.1 IU/L9-10 years: < or =4.5 IU/L11 years: 0.4-8.9 IU/L12 years: 0.5-10.5 IU/L13 years: 0.7-10.8 IU/L14 years: 0.5-10.5 IU/L15 years: 0.4-18.5 IU/L16 years: < or =9.7 IU/L17 years: 2.2-12.3 IU/L≥18 years: 1.0-18.0 IU/LFemales15 days-6 years: < or =3.3 IU/L7-8 years: < or =11.1 IU/L9-10 years: 0.4-6.9 IU/L11 years: 0.4-9.0 IU/L12 years: 1.0-17.2 IU/L13 years: 1.8-9.9 IU/L14-16 years: 0.9-12.4 IU/L17 years: 1.2-9.6 IU/L≥18 years:PremenopausalFollicular: 3.9-8.8 IU/LMidcycle: 4.5-22.5 IU/LLuteal: 1.8-5.1 IU/LPostmenopausal: 16.7-113.6 IU/L |
| Insulin-like growth factor (IGF-1) |  |

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| **Laboratory and Contact** | **Analyte** | **\* CLIA Cert.** | **Matrix** | **Volume** | **Reportable Range, Guidelines,** **Critical Values***Reference ranges will be updated when commercial lab is selected.* |
| ***Children and Adults*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Immune Function* | Yes | Serum | 2 ml |  |
| Ig A, Ig G, Ig M, Ig E |  |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Glycemic Parameters* | Yes |  |  |  |
| Glycosylated hemoglobin (HbA1c) | Whole Blood EDTA | 1 ml;  plus 1 ml reserve | Diabetes Risk[[10]](#footnote-10)Normal: <5.7%Increased Risk Diabetes: 5.7-6.4%Diabetes: ≥6.5% (confirmation required) |
| Glucose, fasting, 8-hour | Serum | 1 ml Glucose/Insulin;1 ml antibodies |  |
| Insulin | <17 µU/ml 8 |
| Pro-insulin | 3.6-22 pmol/L8 |
| C-peptide | 1.1-4.4 ng/mL8 |
| Glutamate Decarboxylase -65 (Anti-GAD 65) | Negative Antibody: DK≤33 8Positive Antibody: DK>33 |
| Thyrosine Phosphatase-like Protein Autoantibodies (Anti-IA2) | Negative Antibody: DK<5 8Positive Antibody: DK≥5 |
| ***Children Only*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Antibodies to measles, mumps, rubella, tetanus, and diphtheria* | Yes | Serum | 1 ml |  |
| **Child Total** | **Serum - 11ml Whole Blood – 2 ml Urine – 16 ml****Red Top 3 x10 ml EDTA Lavender Top 3 ml** |

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| ***Adults Only*** |
| ***Commercial Laboratory (to be determined)\*****Contact:* | *Autoimmune Parameters* | Yes | Serum | 2 ml (for all) |  |
| Rheumatoid Factor (RF) | < 15 IU/mL[[11]](#footnote-11) |
| Antinuclear Antibody (ANA) screen | < or =1.0 U (negative)[[12]](#footnote-12)1.1-2.9 U (weakly positive)3.0-5.9 U (positive)> or =6.0 U (strongly positive) |
| Antinuclear Antibody (ANA) titer |  |
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|  | *Inflammatory Cytokines* |  |  |  |  |
|  | Interleukin 1-β (IL-1β), IL-4, IL-6, IL-8, IL-12, monocyte chemotactic protein-1 (MCP-1), tumor necrosis factor α (TNFα), leptin, adiponectin, resistin, plasminogen activator inhibitor-1 (PAI-1)*.* | No | Serum | 2 ml  | Clinical reference levels not established. |
|  |  |  |  |  |  |
| **Adult Total** | **Serum – 15 ml Whole Blood – 2 ml Urine – 16 ml****Red Top 4 x 10 ml EDTA Lavender Top 3 ml** |

1. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/8320](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/8320) [↑](#footnote-ref-1)
2. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/8440](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/8440) [↑](#footnote-ref-2)
3. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/8472](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/8472) [↑](#footnote-ref-3)
4. University of Southern California Clinical Laboratories Endocrine Services. [↑](#footnote-ref-4)
5. University of Louisville Department of Medicine, Gastroenterology (updated 14 October 2015). [↑](#footnote-ref-5)
6. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/83686](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/83686) [↑](#footnote-ref-6)
7. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/81816](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/81816) [↑](#footnote-ref-7)
8. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/9285](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/9285) [↑](#footnote-ref-8)
9. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/8670](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/8670) [↑](#footnote-ref-9)
10. American Diabetes Association. Standards of Medical Care in Diabetes - 2011. Diabetes Care. January 2011;34(Supplement 1):S11-S61 (subject to periodic update). [↑](#footnote-ref-10)
11. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/9060](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/9060) [↑](#footnote-ref-11)
12. [https://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/9026](https://www.mayomedicallaboratories.com/test-catalog/Clinical%2Band%2BInterpretive/9026) [↑](#footnote-ref-12)