Highlights of CDC’s National Biomonitoring Program

Association of Public Health Laboratories (APHL) Annual Meeting
June 3, 2018

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Chief Medical Officer
Division of Laboratory Sciences

National Center for Environmental Health
Key Biomonitoring Activities

- CDC’s National Biomonitoring Program
- *The National Report on Human Exposure to Environmental Chemicals* and Updated Tables
- State biomonitoring cooperative agreements to build capacity
Biomonitoring is...

- Measuring a chemical, metabolite, or reaction product in human specimens to assess internal exposure
  - Integrates all sources and routes of exposure
  - Trace concentrations, for the most part
- A useful tool for exposure assessment
- Measurement of concentrations, not exposures
  - Exposure biomarker
The National Biomonitoring Program

A federal program that establishes U.S. population-based reference ranges and exposure trends for environmental chemicals.

NHANES
Participant Recruitment and Sample Collection

National Report on Human Exposure to Environmental Chemicals and Updated Tables

Probability sample of civilian, non-institutionalized Americans that provides population-based results.

CDC
Sample Analysis

A comprehensive, ongoing assessment of American’s exposure to environmental chemicals.

NHANES: National Health and Nutrition Examination Survey
What is NHANES?

- National Health and Nutrition Examination Survey
  - Ongoing survey—continuous since 1999
  - Nationally representative sample of civilian, noninstitutionalized US population in the contiguous states
  - About 10,000 participants in 30 counties every 2 years

- Methods
  - Face-to-Face and Computer-Assisted Interviews:
    - Demographics/Socioeconomic
    - Dietary/Nutritional
    - Medical History and Health Behavior
    - Physical Examination
  - Biological Specimen Collection: Blood & Urine

- Sampling design changes over time
- The only national survey that “touches” participants

More at: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm
Mobile Examination Centers (MEC)

www.cdc.gov/nchs/nhanes.html
Biomonitoring in NHANES

- Not all chemicals are measured in everyone, except:
  - Blood Pb, Cd, Hg, Se, Mn: All persons 1 year and older
  - Serum cotinine: All persons 3 years and older
- Most urinary chemical measurements are made in a 1/3 subsample (n~2500) of the participants
  - Ages 6 years and older*
  - Subsamples are determined so they are representative of the U.S. population
- Biomonitoring results are presented in the *National Report on Human Exposure to Environmental Chemicals* and the *Updated Tables*
- Biomonitoring datasets can be downloaded using SAS

*Starting in 2015, urine is collected from participants ages 3 years and older*
## CDC’s National Report on Human Exposure to Environmental Chemicals (1999–2016)*

### Serum Perfluorooctane sulfonic acid (PFOS) (2011 - 2014):‡

<table>
<thead>
<tr>
<th>Survey years‡</th>
<th>Geometric mean (95% conf. interval)</th>
<th>Selected percentiles (95% confidence interval)</th>
<th>Sample size</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>50th</td>
<td>75th</td>
<td>90th</td>
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<tr>
<td><strong>Total</strong></td>
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<tr>
<td>11-12</td>
<td>6.31 (5.84-6.82)</td>
<td>6.53 (5.99-7.13)</td>
<td>10.5 (9.78-11.1)</td>
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<tr>
<td>13-14‡</td>
<td>4.99 (4.50-5.52)</td>
<td>5.20 (4.80-5.70)</td>
<td>8.70 (7.90-9.40)</td>
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<tr>
<td><strong>Age group</strong></td>
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<tr>
<td>12-19 years</td>
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<tr>
<td>11-12</td>
<td>4.16 (3.70-4.68)</td>
<td>4.11 (3.48-4.65)</td>
<td>5.90 (5.14-7.25)</td>
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<tr>
<td>13-14‡</td>
<td>3.54 (3.17-3.96)</td>
<td>3.60 (3.19-4.20)</td>
<td>5.20 (4.60-6.20)</td>
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<tr>
<td>20 years and older</td>
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<tr>
<td>11-12</td>
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<td>7.07 (6.65-7.52)</td>
<td>11.0 (10.4-11.9)</td>
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<tr>
<td>13-14‡</td>
<td>5.22 (4.70-5.81)</td>
<td>5.60 (5.10-6.00)</td>
<td>9.10 (8.20-10.2)</td>
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<tr>
<td><strong>Gender</strong></td>
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<tr>
<td>Males</td>
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<td>11-12</td>
<td>7.91 (7.19-8.70)</td>
<td>8.31 (7.35-9.15)</td>
<td>12.5 (11.4-13.5)</td>
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<tr>
<td>13-14‡</td>
<td>6.36 (5.67-2.70)</td>
<td>6.40 (5.70-7.30)</td>
<td>10.2 (8.70-11.5)</td>
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<tr>
<td>Females</td>
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<td>11-12</td>
<td>5.10 (4.70-5.53)</td>
<td>5.27 (4.67-5.64)</td>
<td>8.57 (7.87-9.30)</td>
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<tr>
<td>13-14‡</td>
<td>3.96 (3.60-4.35)</td>
<td>4.00 (3.60-4.60)</td>
<td>7.20 (6.40-7.70)</td>
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<tr>
<td><strong>Race/ethnicity</strong></td>
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<td>Mexican Americans</td>
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<tr>
<td>11-12</td>
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<td>7.91 (6.18-9.48)</td>
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<td>5.20 (4.60-6.40)</td>
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<tr>
<td>Non-Hispanic blacks</td>
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<tr>
<td>11-12</td>
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<td>6.57 (5.71-7.65)</td>
<td>11.3 (9.74-13.9)</td>
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<td>5.32 (4.12-6.88)</td>
<td>5.30 (4.30-6.80)</td>
<td>10.2 (7.60-13.7)</td>
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<tr>
<td>Non-Hispanic whites</td>
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<td></td>
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<tr>
<td>11-12</td>
<td>6.71 (6.15-7.32)</td>
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<td>13-14‡</td>
<td>5.31 (4.72-5.98)</td>
<td>5.70 (5.10-6.40)</td>
<td>8.90 (8.20-9.90)</td>
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<tr>
<td>All Hispanics</td>
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<tr>
<td>11-12</td>
<td>4.63 (3.86-5.55)</td>
<td>5.18 (4.41-6.19)</td>
<td>8.10 (6.64-9.78)</td>
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<td>13-14‡</td>
<td>3.51 (3.09-3.98)</td>
<td>3.70 (3.20-4.20)</td>
<td>5.50 (4.90-6.40)</td>
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<td>Asians</td>
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<tr>
<td>11-12</td>
<td>7.10 (5.80-8.68)</td>
<td>7.53 (5.96-9.25)</td>
<td>12.6 (10.8-17.0)</td>
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<tr>
<td>13-14‡</td>
<td>6.18 (5.08-7.52)</td>
<td>6.30 (5.00-7.90)</td>
<td>13.2 (9.40-15.4)</td>
</tr>
</tbody>
</table>

*www.cdc.gov/exposurereport/

Limit of detection (LOD, see Data Analysis section) for Survey year 11–12 is 0.2.
‡ See Calculation of PFOS and PFOA as the Sum of Isomers for additional information about Survey years 2013-2014.

- **Metals**
- **Cotinine**
- **NNAL**
- **Dioxins, furans, & PCBs**
- **Organochlorine pesticides**
- **PFAS**
- **Organophosphate & pyrethroid insecticides**
- **Other pesticides (e.g., herbicides, insect repellents)**
- **Parabens**
- **Phthalates & alternative plasticizers**
- **PCP chemicals (e.g., phenols, triclocarban)**
- **PAHs**
- **Perchlorate, nitrate & thiocyanate**
- **VOCs and VOC metabolites**
Updated Tables, March 2018

- Updated Tables reported in two volumes
  - Volume 1 – U.S. general population
  - Volume 2 – Pooled samples, adult cigarette smokers and nonsmokers:
    - POPs and pesticides in individual and pooled samples
    - Special sample of adult smokers and nonsmokers

- New chemical data
  - BPF, BPS in urine
  - Flame retardants in urine (OP FR metabolites)
  - Cobalt, chromium in blood (40+yrs)
  - DiBP, DBP metabolites in urine
  - Heterocyclic amines in urine
  - VOCs in blood (10 new)
Goals of the National Report and Updated Tables

- Assess exposure to various chemicals
  - Which chemicals? Who is exposed? How much?

- Establish US “reference ranges” for these chemicals
  - By age, sex, and racial/ethnic group
  - By smoker vs. nonsmoker status (adults)

- Over time, track changes in these “reference ranges”

- Help set priorities on studies of exposures and health outcomes

Data tables are available for more than 300 chemicals, with results from 1999 to 2016
Flame Retardant Metabolites, 2013-2014
Geometric mean urinary concentration (ng/mL)

Ospina et al., Environ Int 2018;110:32.
Serum Concentrations of Long Chain PFAS in U.S. Children¹, 2013-2014

Serum concentrations in pre-adolescents were similar to adolescents and to the overall U.S. population (ages 12+ years), based on one cycle of NHANES data.

Serum concentrations of Long Chain PFAS in U.S. Children\textsuperscript{1}, 2013-2014

<table>
<thead>
<tr>
<th></th>
<th>3-5 yr</th>
<th>6-11 yr</th>
<th>12-19 yr</th>
<th>All 12+</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFHxS Geometric Mean</td>
<td>0.715</td>
<td>0.913</td>
<td>1.27</td>
<td>1.35</td>
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<tr>
<td>PFHxS 95th Percentile</td>
<td>0.764</td>
<td>0.809</td>
<td>1.35</td>
<td>1.62</td>
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<tr>
<td>PFNA Geometric Mean</td>
<td>3.49</td>
<td>3.19</td>
<td>2.0</td>
<td>2.0</td>
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<tr>
<td>PFNA 95th Percentile</td>
<td>0.764</td>
<td>0.809</td>
<td>0.599</td>
<td>0.675</td>
</tr>
</tbody>
</table>

Serum concentrations in pre-adolescents were similar to adolescents and to the overall U.S. population (ages 12+ years), based on one cycle of NHANES data.

Monitor Time Trends

- Exposure to PFOS with Production Changes
  - U.S. manufacture of PFOS precursors phased out in 2000-2002
  - PFOS serum concentrations declined by 83% since 1999-2000 (PFOS precursors are still produced in China)

PFOS Precursor Production

PFOS Exposure - NHANES

1996 FQPA and Exposure to Organophosphate Insecticides

Figure 3.4
Total Amount of Organophosphate and All Other Insecticide Active Ingredients Used in the United States in All Market Sectors, 1990–2007

Phase-out residential use of chlorpyrifos (2000-1)

Downtrend in exposure to organophosphate insecticides and.....

GM urinary level (µg/L)

TCPy (chlorpyrifos) ↓ 56%
3-PBA (pyrethroids) ↑ 44%

NHADES cycle

1999-2000
2001-2002
2007-2008
2009-2010
Effect of Replacement/Alternative Chemicals

- Some exposures increased: DiNP (↑265%)
- Some exposures decreased: DEHP (↓67%)
- Legislative actions and public scrutiny
Final Thoughts

- NHANES provides ongoing exposure of the U.S. general population to select environmental chemicals

- NHANES has limitations
  - Cross-sectional design
  - National estimates: no geographical and limited seasonal information
  - No data for specific population groups, sources, or uses of chemicals
  - Limited data for children <6 years of age
Final Thoughts (continued)

- Need studies to assess exposures & health in select populations
  - State Biomonitoring programs
  - National Biomonitoring Network

- Biomonitoring NHANES data is useful to support public health guidelines
Thank You!

Questions?

For more information, contact NCEH
1-800-CDC-INFO (232-4636)
Follow us on Twitter @CDCEnvironment

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