Role of Biomonitoring in Exposure and Community Human Health Studies

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Outline

I. Types of health studies and exposure assessment
II. Exposure assessment issues – chemical dependent
III. Interpreting biological monitoring data
IV. Example of community biomonitoring
I. Types of Health Studies and Exposure Assessment

Purpose: Define any association between exposure and disease

Question: How best to assess exposure?
Types of Health Studies: Cohort (Longitudinal)

Exposed
- Develop disease
- Do not develop disease

Not Exposed
- Develop disease
- Do not develop disease
Types of Health Studies: Case/Control

- Exposed
- Not exposed

Disease

- Exposed
- Not exposed

No Disease
Types of Health Studies: (Cross-Sectional)

Define Population

Assess Exposure and Disease

Exposed Diseased
Exposed Not Diseased
Not Exposed Diseased
Not Exposed Not Diseased
Environmental Public Health Continuum

For health studies: with certain caveats, the “closer” exposure is assessed to the effects, the more “accurate” is the relation between exposure and effects defined.
Exposure Pathway

Source

Water, Air, Food, Soil, Dust, Sediment, Personal Care Products

Exposure Dose

Absorption following:

Distribution

Metabolism

Elimination

Internal Dose

Inhalation

Ingestion

Dermal Contact

Target Organ Dose

Elimination

Biologically Effective Dose

Effect

Predicting Adverse Health Outcomes Following Human Exposure to Environmental Chemicals is Problematic or “Why do people respond differently to similar exposures?”

- Genetic factors
- Demographic factors (age, sex, geography)
- Environmental and behavioral stressors
- Nutritional status
- Other exposures

Biomonitoring for Disease Prevention

- Susceptible populations
- Reference range
- Emerging chemicals
- Trends
- Reference range
- Highly exposed
- Emergency response
- Epidemiology
- Preclinical indicators
- Clinical studies
- Exposure pathway
- Health effects
- Risk assessment
- Reference/acceptable doses
- Research & policy

Biomonitoring

- Exposure assessment
- Public health actions
II. Exposure Assessment Issues Depending on the Chemical
Two Classes of Chemicals

- Persistent in the Body (Long Half Lives)
- Nonpersistent in the Body (Short Half Lives)
Pharmacokinetics of Environmental Chemicals in Body and What Matrices Are Available for Analyses

Ingestion
- Gastrointestinal Tract
  - Liver
  - Bile
  - Feces

Inhalation
- Lung
  - Alveoli
  - Expired Air

Dermal
- Primary Deposition Sites
  - Fat
  - Bone
  - Soft Tissues

Secretory Structures
- Secretions
  - Saliva
  - Sweat
  - Milk

Post-Exposure Fate of a Persistent Chemical in Blood and Urine

Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine

If chemical forms an adduct: extends time window of exposure

Timing of Urine Collection May be Critical
Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine

**Urine**
- Metals (13)
- PAH metabolites
- Phthalate metabolites
- Pesticides
  - Organophosphorus
  - Carbamates
  - Herbicides
  - Pyrethroid
- Repellants
- Phytoestrogens

**Blood**
- Lead
- Cadmium
- Mercury

**Serum**
- Dioxins
- Furans
- PCBs
- Organochlorine pesticides
- Cotinine

*Released: July 2005*
[www.cdc.gov/exposurereport](http://www.cdc.gov/exposurereport)
Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine

Barr et al., Environ Health Perspect 113:1083-1091 (2005)

Nonpersistent Chemicals: Episodic Exposures

No “good” way to assess exposure!!
Post-Exposure Fate of a Nonpersistent Chemical in Blood and Urine
III. Interpreting Biological Monitoring Data
Life Stages of Children: Know Availability of Matrices

Relative Importance of Various Biological Matrices for Measuring Exposure During the Different Life Stages

<table>
<thead>
<tr>
<th>Matrices</th>
<th>Adult preconception</th>
<th>Fetal</th>
<th>0-1 year</th>
<th>2-3 years</th>
<th>4-11 years</th>
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<td></td>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
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<tr>
<td>Blood (whole)</td>
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<td>Blood (serum)</td>
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<td>Saliva</td>
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<td>Hair</td>
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<td>Nails</td>
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<td>Feces</td>
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<tr>
<td>Semen</td>
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<td>Breath</td>
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<td>Teeth</td>
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<td>3</td>
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<tr>
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<td>3</td>
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<tr>
<td>Blood (maternal)</td>
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<td>1</td>
<td>3</td>
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<tr>
<td>Urine (maternal)</td>
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<td>Hair (maternal)</td>
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Persistent Organic Chemicals

Barr, Wang, and Needham. EHP 113:1083-91(2005)
Creatinine in Urine:
To Adjust or Not Adjust
Creatinine Variability Among Populations

Comparison of Urinary Data Based on Age, Race, and Sex

Barr et al., Environ Health Perspect 113:192-200 (2005)
IV. Community Monitoring Example
Seveso, Italy Scenario

- **Saturday – July 10, 1976**
  - Explosion in a TCP reactor
  - Atmospheric release of kilogram amount of 2,3,7,8-TCDD

- **People potentially exposed**
  - A Zone – 736
  - B Zone – 4,737
  - R Zone – 31,800

- **Highest measured level**
  - 56,000 ppt (Oct. 1976)
Map of Seveso Showing Contaminated Area
Seveso, Italy

- Acute exposure
- Wide range of exposure
- Both genders
- Adults and children
- Serum specimens saved from 1976-1985 medical exams
2378-TCDD Levels in Persons in Seveso, Italy Study

Change in Sex Ratio with Exposure to Dioxin

- Seveso, Italy Dioxin Explosion
  - July 10, 1976 factory explosion
  - A Zone (736 people)
- Normal sex ratio (106 M and 100 F)

Change in Sex Ratio with Exposure to Dioxin

- 74 Total births from 9 months after accident to December 1984 (~1 half-life of serum TCDD)
  - Excess of females (26 M vs. 48 F)
  - $X^2$ (P < 0.001)
- From 1985 to 1994
  - 60 Males and 64 Females

Sex Distribution of Children Born April 1977 – December 1984 to Parents with Measured Serum TCDD Levels (ppt) in Zone A – Seveso, Italy

<table>
<thead>
<tr>
<th>Father’s TCDD Level</th>
<th>Mother’s TCDD Level</th>
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<tr>
<td>2340</td>
<td>960</td>
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<tr>
<td>1490</td>
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<td>1420</td>
<td>463</td>
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<td>30</td>
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<tr>
<td>29</td>
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</table>

Paternal Concentrations of Dioxin and Sex Ratio Offspring

In Seveso Area:
- From 1977-1996: 346 girls, 328 boys born
- Measured 1971, 1977 TCDD levels in 239 men, 296 women
- No association with lowered sex ratio with maternal TCDD levels
- Lower sex ratio with increasing paternal serum TCDD levels (p=0.008)
- Fathers exposed when <19 years sired significantly more girls (sex ratio = 0.38; 95% CI = 0.30 – 0.47)