Clinical Toxicology in the Paediatric Patient

Poison Awareness,
Everybody’s Business.

Poison Prevention Week
May 28 to June 4, 2006
Kingston, Jamaica

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WHO CEH Training Project
CHILDREN ARE NOT LITTLE ADULTS

Until recently, childhood environmental health risks were considered as scaled down risks from adult occupational risks.

Giotto, National Gallery, Washington DC
CHILDREN ARE NOT LITTLE ADULTS

1. Different and unique exposures
2. Dynamic developmental physiology
3. Longer life expectancy
4. Politically powerless

Raphael, National Gallery of Art, Washington, DC
1. DIFFERENT AND UNIQUE EXPOSURES

- **Unique exposure pathways**
  - Transplacental
  - Breastfeeding

- **Exploratory behaviours leading to exposures**
  - Hand-to-mouth, object-to-mouth
  - Non-nutritive ingestion

- **Stature and living zones, microenvironments**
  - Location – lower to the ground
  - High surface area to volume ratio

- **Children do not understand danger**
  - Pre-ambulatory
  - Adolescence “high risk” behaviours
1. DIFFERENT AND UNIQUE EXPOSURES

TRANSPLACENTAL

Lessons from pharmaceuticals: thalidomide, diethylstilbestrol (DES), alcohol

- Many chemicals cross the placenta
  - Lead, mercury, polychlorinated biphenyls (PCBs)…
  - Substances of abuse: alcohol, methadone

- Some physical factors may affect the fetus directly
  - Ionizing radiation, heat

Maternal exposures do matter!
1. DIFFERENT AND UNIQUE EXPOSURES

BREASTFEEDING

- Breast milk is the safest and most complete nutrition for infants
  - Mothers should avoid toxic exposures
  - Milk (human, cow, sheep) can be a marker of environmental contamination

- DDT, DDE, PCBs, TCDD (dioxins), nicotine, lead, methylmercury, alcohol

- Morbidity rarely seen
  - Unusual exposure event
  - Mother also ill
1. DIFFERENT AND UNIQUE EXPOSURES

BEHAVIOUR AND SOIL CONSUMPTION

mg/day

Child (mean)
Child (upper percentile)
Adult

US EPA
1. DIFFERENT AND UNIQUE EXPOSURES

STATURE AND BREATHING ZONES

Guzelian, ILSI, 1992
1. DIFFERENT AND UNIQUE EXPOSURES

STATURE AND BREATHING ZONES

WHO
1. DIFFERENT AND UNIQUE EXPOSURES

SIZE AND SURFACE AREA

- Newborn
- Toddler
- Child
- Adult
1. **DIFFERENT AND UNIQUE EXPOSURES**

**CHILDREN DO NOT RECOGNIZE DANGER**

- Pre-ambulatory children are unable to remove themselves from danger

- Pre-reading children cannot read warning signs and labels

- Pre-adolescent and adolescent children may take unreasonable risks because of cognitive immaturity
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

MORE VULNERABLE

Xenobiotics may be handled differently by an immature body.

- Increased energy, water and oxygen consumption of anabolic state
- Absorption
- Biotransformation
- Distribution
- Elimination
- Critical windows of development
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

OXYGEN DEMAND

Minute ventilation per kg body weight/day

Litres

<table>
<thead>
<tr>
<th>Age in years</th>
<th>&lt;1</th>
<th>4</th>
<th>12</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litres/kg/day</td>
<td>600</td>
<td>500</td>
<td>400</td>
<td>200</td>
</tr>
</tbody>
</table>

Miller, Int J Toxicology (2002) 21(5);403
## 2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

### CALORIE AND WATER NEEDS

#### Maintenance Requirements

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Cal/kg/day</th>
<th>ml/kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>110-150</td>
<td>10-12</td>
</tr>
<tr>
<td>1.0-3.0</td>
<td>130-170</td>
<td>12-14</td>
</tr>
<tr>
<td>4.0-6.0</td>
<td>150-200</td>
<td>14-16</td>
</tr>
<tr>
<td>7.0-10.0</td>
<td>170-220</td>
<td>16-18</td>
</tr>
<tr>
<td>11.0-14</td>
<td>190-240</td>
<td>18-20</td>
</tr>
<tr>
<td>15-18</td>
<td>210-260</td>
<td>20-22</td>
</tr>
<tr>
<td>19-24</td>
<td>230-280</td>
<td>22-24</td>
</tr>
<tr>
<td>25-50</td>
<td>250-300</td>
<td>24-26</td>
</tr>
<tr>
<td>50+</td>
<td>270-320</td>
<td>26-28</td>
</tr>
</tbody>
</table>

[Bar chart showing calorie and water needs by age group.]
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

ABSORPTION

- A child is building the “body for a lifetime”

- The demands of rapid growth and development
  - Require higher breathing rate, caloric and water intakes
  - Satisfied by enhanced absorption and retention of nutrients

For example:

- GI absorption of lead in toddler: 40–70% of oral dose (1/3 retention)
- GI absorption of lead in non-pregnant adult: 5–20% (1% retention)
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

WINDOWS OF DEVELOPMENT

Schematic illustration of the sensitive or critical periods in human development. Red denotes highly sensitive periods; yellow indicates stages that are less sensitive to teratogens.

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

WINDOWS OF DEVELOPMENT: FATHERS AND THEIR OFFSPRING

- Paternal exposure to: Hg, ethylene oxide, rubber chemicals, solvents, linked to spontaneous abortion
- Paternal occupation: Painters – anencephaly
  \[\text{Bearer, Am J Epidemiol, 1990, 131(3):517}\]
  Mechanics, welders – Wilms tumour
  \[\text{Olshan, Cancer Res. (1990) 50(11):3212}\]
  Textiles – stillbirth, pre-term delivery

Possible mechanism: impairment of a paternal gene required for the normal growth and development of the fetus

“The special and unique vulnerability of children to environmental hazards” Bearer, Neurotoxicology, 2000, 21(6):925
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

WINDOWS OF DEVELOPMENT: MOTHERS AND THEIR OFFSPRING

Pre-conception
PCBs and Pb maternal body burdens are linked to abortion, stillbirth and learning disabilities
Folate deficiency leads to neural tube defects

In utero
Thalidomide → phocomelia
DES → vaginal cancer
X-rays → leukaemia
Heat → neural tube defects
Alcohol → FAS (fetal alcohol syndrome)
Lead → Neurodevelopmental effects
Methyl mercury
PCBs
2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

WINDOWS OF DEVELOPMENT: BIRTH TO ADOLESCENCE

- **Vital organ growth**
  - Brain
  - Lungs
  - Kidneys
  - Reproductive organs

- **Physiological function**
  - Central nervous system
  - Immune system
  - Endocrine system
3. LONGER LIFE EXPECTANCY

- Exposures early in life permit manifestation of environmental illnesses with long latency periods
  - More disease
  - Longer morbidity

Children inherit the world WE make

WHO
4. POWERLESS POLITICALLY

- No political voice
- Advocacy by health sector
- Environmental laws and regulations
  - Local
  - National
  - International
COMPLEX ENVIRONMENT OF CHILDREN AND ADOLESCENTS

HAZARDS
- Physical
- Chemical
- Biological

MEDIA
Water - Air - Food - Soil - Objects

ACTIVITIES
Learning, Working, Eating, Drinking, Sleeping, Breathing, Smoking,
Doing sports, Playing, « Testing », Scavenging

SETTINGS
- Rural / urban
- Home
- School
- Playground
- Field
- Street
- Workplace

SUSCEPTIBILITIES
- Critical windows / timing
- Age
- Nutritional status
- Poverty

OUTCOME-EFFECTS
- Organs
- Systems
- Functions
- Development
- Survival

Photo credit US NIEHS CERHR logo
CRITICAL ROLE OF HEALTH AND ENVIRONMENT PROFESSIONALS

- Diagnose and treat
- Publish, research
  - Sentinel cases
  - Community-based interventions
- Educate
  - Patients and families
  - Colleagues and students
- Advocate
- Provide good role model
WHAT IS THE PEDIATRIC ENVIRONMENTAL HISTORY?

- A set of basic and concise questions
- Part of the standard medical history, with issues:
  - General
  - Specific
  - Age- and gender-related
- Tailored according to the local situation, needs and capacities of:
  - Industrialized countries
  - Developing regions
KEY AREAS TO ADDRESS

1. What are the potential environmental hazards?

2. How, when and where are children exposed?

3. What are the main effects?
DEVELOPING AND USING THE PEH

- Set of questions to be prepared locally

- Taking into consideration
  1. Potential environmental hazards
  2. How are children/adolescents exposed?
  3. Health and developmental effects

- Addressing public health issues

- Harmonized - locally and internationally
WHEN AND HOW IS THE HISTORY TAKEN?

- Symptomatic or asymptomatic children
- Initial basic set of questions
- Detailed questions in special cases
- Clear formulation of specific questions to parents, children, caregivers and teachers
- Include home/school/playground audit
- The “green page” in a clinical record
### World Health Organization

**Children's Environmental Information: "Green Page"**

**Patient's name**: [Redacted]

**Address**: [Redacted]

**Date of birth**: [Redacted]

**Sex**: [Redacted]

**Occupation**: [Redacted]

**Environment**

**Building**
- Home
- School or child-care
- Recreation place
- Community

**Geographical area**
- Rural
- Urban
- Part-urban

**Food**

**Air quality**

**Water quality**

**Soil, type, and quality**

**Excreta disposal**

**Solid waste disposal**

**Noise**

**Chemicals**

**Traffic**

**Does the mother/caregiver express concerns about the environment? Which ones? Why?**

**Are there any well-known environmental risk factors in the area? Which ones?**

**Mother's and father's occupation**

**Is there exposure to trauma/punitive actions?**

**Are there pet animals at home and in the surroundings? Which ones?**

**Are there venues of clean? Which ones?**

**Is there exposure to extreme temperatures? Describe**

**Has the child suffered traffic-related injuries? Describe**

**Has the child suffered from related injuries or falls? Describe**

**Has the child been exposed to chemical toxicants? Describe**

**Has the child had poisoning due to chemicals and/or food poisoning? Describe**

**Observations (other relevant information)**

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### American Academy of Pediatrics: [www.aap.org](http://www.aap.org)

### ATSDR, Agency for Toxic Substances and Disease Registry: [www.atrsdr.cdc.gov](http://www.atrsdr.cdc.gov)

### Children's Health and the Environment: [www.who.int/ceh](http://www.who.int/ceh)
ENVIRONMENTAL RISK FACTORS AND LONG TERM CHILDREN'S STUDIES

- Chemicals
- Physical
- Biological
- Psychosocial
- Built environment
- Sanitation
- Adequate nutrition
- Media impact
- Physical activities
- Social network and participation
- War and conflict
- Socioeconomic changes
- Life crises
EXAMPLES OF QUESTIONS: WHAT ARE THE CHILD'S ACTIVITIES?

**Hobbies**
- Painting – paint & solvents?
- Model-building – glue & solvents
- Pottery – pigments, paints?
- Gardening – pesticides?
- Woodwork – chemicals?

**Activities**
- Eating habits (type of diet, food quality).
- Drinking habits (alcohol use and abuse, soft drinks)
- Playing habits
- Learning habits
- Working habits
- Scavenging (time spent near garbage)
- Exploring
- Testing (trying drugs, eating unknown berries)

**Sports**
- Type of sport
- Sports area
- Injuries
- Toxic exposures
- Use of energizing drugs
EXAMPLES OF QUESTIONS: WHAT ARE THE CHILD'S BEHAVIORS?

**Personal hygiene and habits**

- How often does the child bathe? Where? With what?
- Are the clothes washed regularly? What type of diapers are used?
- Does the child have lice? How is the infestation treated?
- Does the child play on the floor? Carpet?
- How and how often is the child’s bedroom and play area cleaned? Which chemicals are used to clean the home?
- Does the child have pica?
- Does the child have hand-to-mouth activities?

**Cultural history**

- Use of cosmetics
- Use of alternative medicines
- Cultural practices
- Religious practices
- Traditions involving the use of chemical substances

**Transport**

- What transport does the child use?
  - individual or collective;
  - bicycle;
  - motorcycle;
  - horse; or other.
We hold our future in our hands
and it is our children

Poster Contest by HRIDAY with support from WHO SEARO
ACKNOWLEDGEMENTS

WHO is grateful to the US EPA Office of Children’s Health Protection for the financial support that made this project possible and for the data, graphics and text used in preparing these materials for a broad audience.

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