TRAINING FOR THE HEALTH SECTOR

CHILDREN ARE NOT LITTLE ADULTS

Children's Health and the Environment

CHEST Training Package for the Health Sector

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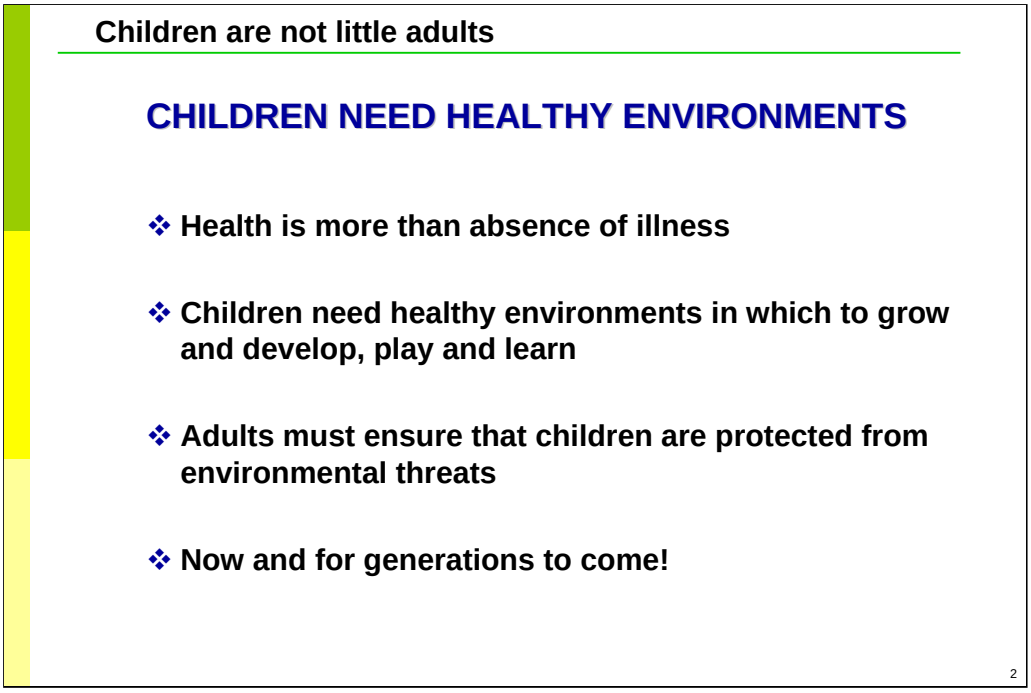
<<NOTE TO USER: Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation.>>

This module is based upon the WHO training module "Children are not little adults". First draft prepared by Katherine M. Shea, MD MPH, USA.



All children deserve the right to grow up in a healthy environment where they can reach their full potential as citizens of the world. Sustainable development has at its core healthy children. Health is much more than mere absence of illness. It is the responsibility of today's adults to identify hazards and conditions that impair children's ability to grow and mature safely and in good health.

Health is more than absence of illness

Children need healthy environments in which to grow and develop, play and learn

Their environments are complex, multiple and changing.

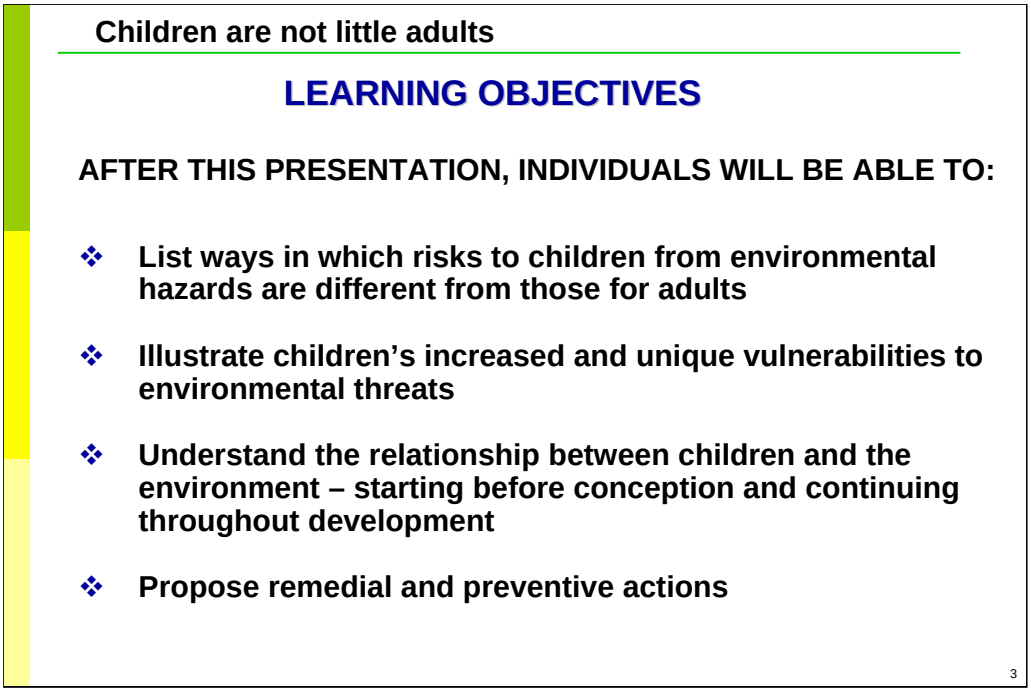
Adults must ensure that children are protected from:

- exposures to toxic chemicals, physical injury and infections;
- poverty and malnutrition; and
- child labour.

Now and for generations to come!

<<NOTE TO USER: Although the term "children" is used to cover all age-groups from birth to age 19, strict WHO terminology refers to "newborns" (1 to 28 days), "infants" (up to 12 months), "children" (from 1 up to 10 years), "adolescents" (10 to 19 years). Please note that UNICEF and other organizations may use different age groupings (UNICEF considers children as being up to 18 years old).>>

Ref: Children in the New Millennium; Environmental Impact on Health. UNEP/UNICEF/WHO, 2002 (www.who.int/water_sanitation_health/hygiene/settings/millennium/en/).



After this talk, we hope that you will be able to satisfy these four learning objectives:

• Be able to list ways in which risks to children from environmental hazards are different from those for adults.

• Be able to illustrate children's increased and unique vulnerabilities using real-world examples of environmental threats:

  – biological;

  – physical; and

  – chemical.

• Understand that the relationship between children and their environment begins before conception and continues throughout development.

• Propose remedial and preventive actions.

<<READ SLIDE.>>

Refs:

•*ATSDR Case Study on Pediatric Environmental Health*, 2002 (www.atsdr.cdc.gov/HEC/CSEM/pediatric/index.html)

•Etzel R. *Pediatric environmental health, 2nd ed.* American Academy of Pediatrics, 2003.

Children are not little adults

CHILDREN ARE NOT LITTLE ADULTS

Giotto, National Gallery, Washington DC

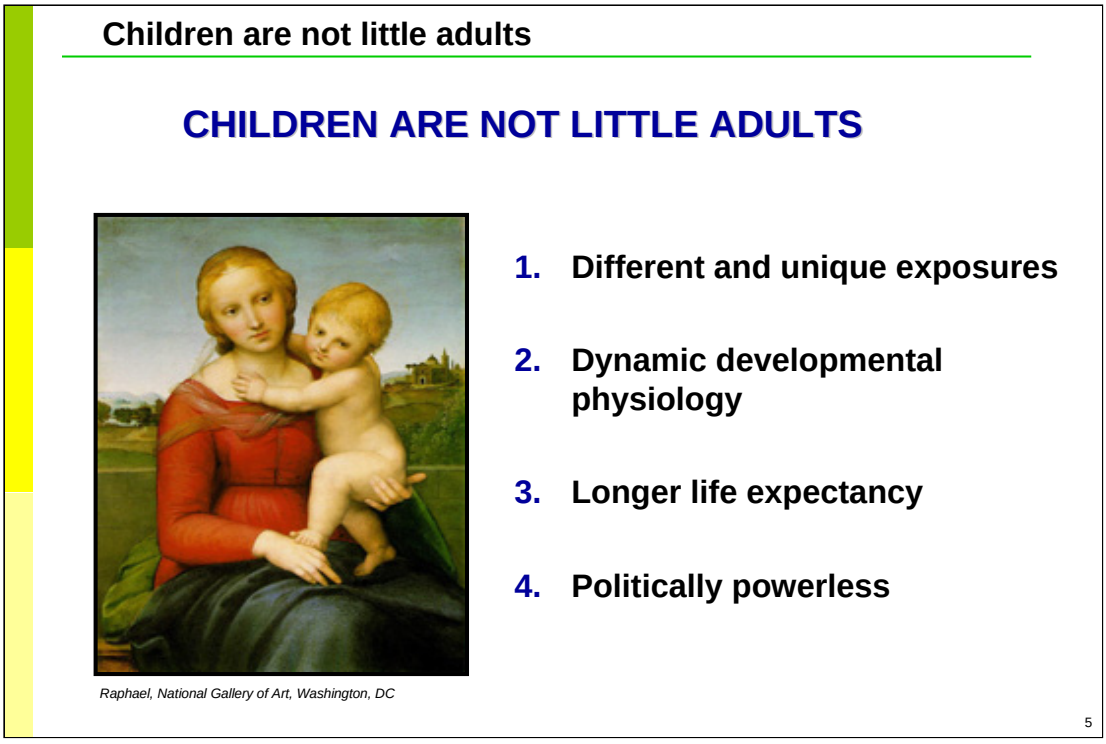
Until recently, childhood environmental health risks were considered as scaled down risks from adult occupational risks

4

Until about 500–600 years ago, artists in Western traditions represented children as miniaturized adults just as we see in this 13th century icon. Until about 50–60 years ago, doctors following the standard medical practices of the developed countries understood paediatric exposures as simple extrapolations from adult occupational exposures.

<<NOTE TO USER: Use image which is regionally or culturally appropriate for illustrating the inaccuracy of thinking of children's environmental risks simply as scaled down adult risk.>>

Image: National Gallery of Art, Smithsonian Institute, Washington, DC.



The artists of the Renaissance realized that children are not simply miniaturized adults: they have big heads, long trunks and short limbs, as seen in this "Madonna and Child" by Raphael.

<<NOTE TO USER: Replace with culturally/regionally appropriate image to illustrate the physical differences between babies and adults.>>

We now recognize that children, including the embryo, fetus, infant and all life stages until the completion of adolescence, are often at a different and increased risk from environmental hazards from that of adults, for reasons that can be divided into four major categories.

1. Children often have different, and sometimes unique, exposures to environmental hazards from those of adults.

2. Due to their dynamic developmental physiology children are often subjected to higher exposures to pollutants found in air, water and food. These exposures may be handled quite differently by an immature set of systems to the way they are dealt with in adults. Furthermore, the developmental component of a child's physiology is changing: maturing, differentiating and growing in phases known as "developmental windows". These "critical windows of vulnerability" have no parallel in adult physiology and create unique risks for children exposed to hazards that can alter normal function and structure.

3. Children have a longer life expectancy. Therefore they have longer to manifest a disease with a long latency period, and longer to live with toxic damage.

4. Finally, children are politically powerless; they are defenceless. With no political standing of their own, they must rely on adults to protect them from toxic environmental agents. Each of these points is illustrated in more detail in the following slides.

Image: National Gallery of Art, Smithsonian Institute, Washington, DC.

Children are not little adults

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

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Children have unique exposure pathways. They can be exposed *in utero* to toxic environmental agents which cross the placenta. Such exposures can be chemical (pollutants and pharmaceuticals), physical (radiation, heat) and biological (viral, parasitic). They can also be exposed to pollutants that pass into their mother's milk. Neither of these routes of exposure occur in adults or older children.

Children also have pathways of exposure that differ from those of adults due to their size and developmental stage. For example, young children engage in normal exploratory behaviours including hand-to-mouth and object-to-mouth behaviours, and non-nutritive ingestion which may dramatically increase exposure over that in adults.

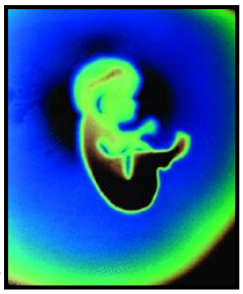
Children's physical differences also cause them to reside in a different location in the world, i.e. closer to the ground. Heavy pollutants such as mercury are concentrated in their breathing zone and deliberate applications of pesticides and cleaning solutions make them more readily accessible to small children. Because they are small, they have a high surface area to volume ratio and can have dramatically higher absorption through dermal contact than adults.

And, they may have much more limited ability to understand and move out of danger, both from toxic agents and dangerous situations which could result in injury. This characteristic is obvious in the pre-ambulatory phase, but persists through exploratory toddler behaviour and even into the high-risk behaviours seen in adolescence.

Children are not little adults

1. DIFFERENT AND UNIQUE EXPOSURES

TRANSPLACENTAL



EHP

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!

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Until the disasters of phocomelia caused by thalidomide and clear cell carcinoma caused by diethylstilbesterol, it was widely believed that the placenta formed an impregnable, protective barrier between the mother and the child. Now we know that this is far from true. Many pharmaceuticals cross the placenta as do many pollutants. In addition, physical environmental hazards such as radiation and heat can harm a growing fetus. The issue of environmental health of children begins with the parents, and concerns about new exposures begin in utero.

Refs:

•Brent. Environmental causes of human congenital malformations: The pediatrician's role in dealing with these complex clinical problems caused by a multiplicity of environmental and genetic factors. *Pediatrics,* 2004, 113:957.

•Walkowiak. Environmental exposure to polychlorinated biphenyls and quality of the home environment: effects on psychodevelopment in early childhood. *Lancet,* 2001, 358:1602.

There is uncertainty whether environmental levels of exposure to polychlorinated biphenyls (PCBs) adversely affect mental and motor development in early childhood. We aimed to establish whether such an effect is of only prenatal or additional postnatal origin, and if a favourable home environment can counteract this effect. Methods: *Between 1993 and 1995 we recruited 171 healthy mother–infant pairs and prospectively measured psychodevelopment in newborn infants aged 7, 18, 30 and 42 months. We estimated prenatal and perinatal PCB exposure of newborn babies in cord blood and maternal milk. At 42 months we measured postnatal PCB concentrations in serum. At 18 months the quality of the home environment was assessed using the Home Observation for Measurement of the Environment scale. Mental and psychomotor development of the children were assessed using the Bayley Scales of Infant Development until 30 months and the Kaufman Assessment Battery for Children at 42 months.* Findings: *Negative associations between milk PCB and mental/motor development were reported at all ages, becoming significant from 30 months onwards. Over 30 months, for a PCB increase from 173 (5th percentile) to 679 ng/g lipids in milk (95th percentile) there was a decrease of 8.3 points (95% CI -16.5 to 0.0) in the Bayley Scales of Infant Development mental scores, and a 9.1 point decrease (95% CI -17.2 to -1.02) in the Bayley Scales of Infant Development motor scores. There was also a negative effect of postnatal PCB exposure via breastfeeding at 42 months. Home environment had a positive effect from 30 months onwards (Bayley Scales of Infant Development mental score increase of 9.4 points [95% CI 2.2–16.7]). Interpretation: Prenatal PCB exposure at current European background levels inhibits, and a favourable home environment supports, mental and motor development until 42 months of age. PCB exposure also has an effect postnatally.*

EHP Image from NIEHS Webpage

Children are not little adults

1. DIFFERENT AND UNIQUE EXPOSURES

BREASTFEEDING

WHO

- **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

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Breast milk is another unique source of exposure for very small children. It is clear that many environmental chemicals pass into breast milk, particularly lipophilic chemicals. Morbidity from such exposures is rare and is associated with unusual high-exposure events during which the mothers are also ill. Consequently, *fear of chemical exposures should not cause a healthy mother to cease breastfeeding*. For example, it is known that mercury, PCBs, lead and other POPs are present in human breast milk, but this route of exposure has not been shown to be damaging in the absence of maternal illness. Furthermore, the milk of other mammals, such as cows, often used as the basis for infant formula, is also subject to environmental contamination, and may contain higher levels of some pollutants than human milk. The condition of human milk is thus an important indication of the level of environmental contamination in the world the infant is entering, but breast milk should still be the food of first choice for any infant of a healthy mother. **<<READ SLIDE.>>**

<<NOTE TO USER: replace with image of nursing mother appropriate to the region/country.>>

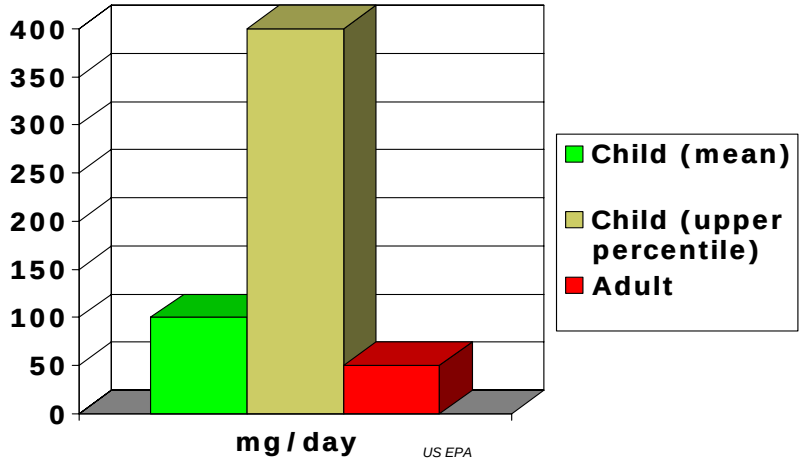
Ref: Pronczuk. Global perspectives in breast milk contamination: Infectious and toxic hazards. *Environ Health Perspect*, 2002, 110:A349.

Breast milk is the natural and optimal food for infants. In addition to meeting nutritional needs, it provides numerous immunological, developmental, psychological, economic and practical advantages. It has been postulated that breastfeeding may also be involved in the prevention of some adult health problems such as diabetes and coronary heart disease. Malnutrition among infants and young children, which remains one of the most severe global public health problems, is among the main reasons that the World Health Organization (WHO) so strongly supports breastfeeding. However, WHO recognizes the growing concern expressed by scientists, health professionals, environmentalists and mothers about the potential risks posed by the presence of toxicants and infectious agents in breast milk. In this paper we review the main infectious hazards (tuberculosis, hepatitis B and human immunodeficiency virus) and selected chemical hazards (tobacco, persistent contaminants) and the activities undertaken by WHO. We conclude that in cases where there is a high degree of pollution from chemical sources occurring simultaneously in a bacterially contaminated environment, the choice is not simply between polluted breast milk and risk-free substitutes. Rather, informed choice is based on assessing the known and unknown risks of artificial feeding versus the unknown, but potential, risks of chemical contamination of breast milk. Clearly, the possible toxicity of compounds requires further investigation. Of much greater importance, however, are effective measures to protect the environment for the entire population by controlling the use of these toxic products. Current scientific evidence does not support altering WHO's global public health recommendation of exclusive breastfeeding for 6 months followed by safe and appropriate complementary foods, with continued breast-feeding, up to 2 years of age or beyond.

Children are not little adults

1. DIFFERENT AND UNIQUE EXPOSURES

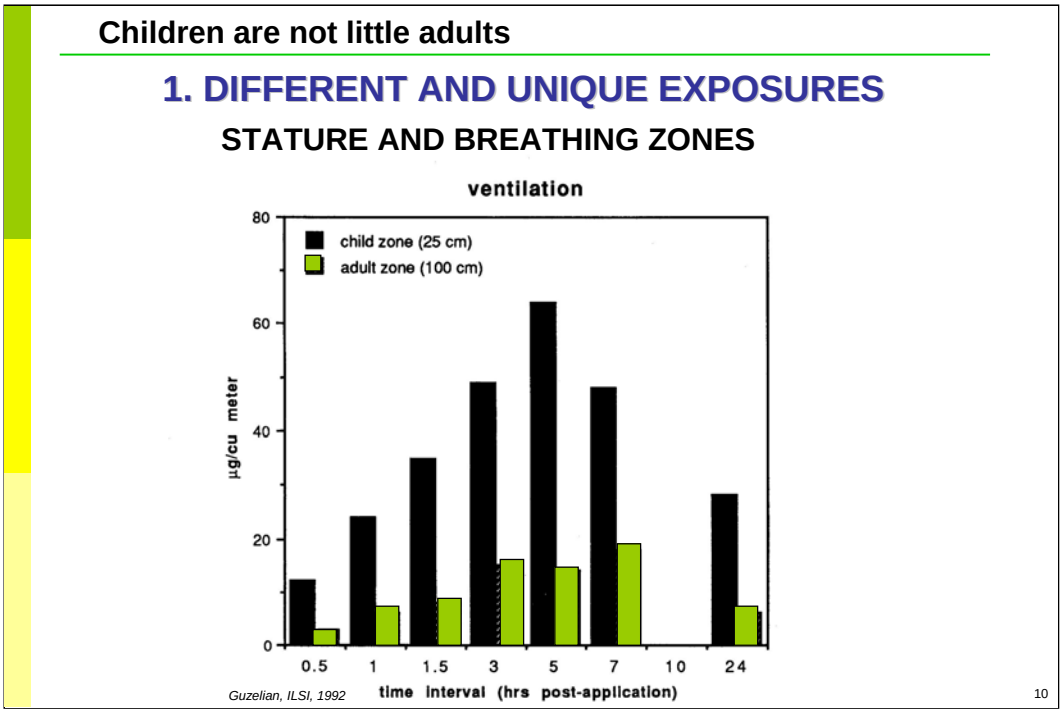
BEHAVIOUR AND SOIL CONSUMPTION



9

Exploratory behaviour is exemplified by hand-to-mouth activity; developmentally maximum in children between 1 and 3 years of age. This graph shows US EPA estimates of soil consumption of children and adults in the USA. The average child ingests twice as much soil as an adult, but a child in the upper percentile can ingest eight times more soil than an adult. Children often learn by putting things in their mouths and can ingest significant quantities of contaminated soil, dust and dirt at early ages.

Source: United States Environmental Protection Agency. *Child-specific exposure factors handbook (Interim report)* (www.epa.gov/ncea/pdfs/efh/front.pdf).



Children are smaller than adults: they live in a different zone in the world. Here is an example of different exposures in different breathing zones. Measurements inside homes following pesticide applications find that concentrations are always highest closest to the floor, where children live. Because children breathe more air, and the air is more heavily contaminated in their living zone due to patterns of evaporation (re-volatilization) after applications to baseboards, they are exposed to more contaminant than are adults. In addition we know that significant pesticide residues can remain on plush toys after application and undergo re-volatilization and secondary deposition for two or more weeks, leading to increased exposures through non-nutritive ingestion as discussed in relation to the previous slide.

Figure: Eds. Guzelian. *Similarities and differences between children and adults; implications for risk assessment.* ILSI, 1992. *Reproduced with permission from International Life Sciences Institute*

Ref: Gurunathan. Accumulation of chlorpyrifos on residential surfaces and toys accessible to children. *Environ Health Perspect* , 1998, 106:9.

Quantitative examination of major pathways and routes of exposure to pesticides is essential for determining human risk. The current study was conducted in two apartments and examines the accumulation of the pesticide chlorpyrifos in childrens' toys after the time suggested for re-entry after application. It has been established for the first time that a semivolatile pesticide will accumulate on and in toys and other sorbant surfaces in a home via a two-phase physical process that continues for at least 2 weeks postapplication. A summation of the above for a 3–6-year-old child yielded an estimated nondietary total dose of 208 microg/kg/day. Potential exposure from the inhalation pathway was negligible, while dermal and nondietary oral doses from playing with toys contributed to 39 and 61% of the total dose, respectively. If children with high frequency mouthing behaviour are considered as candidates for acute exposure to chlorpyrifos residues, the estimated acute dose could be as high as 356 microg/kg/day. Routine reapplication of pesticides could lead to continued accumulation in toys and other sorbant surfaces, e.g. pillows, with large sorbant reservoirs, which can become a long-term source of exposure to a child. Estimates of a child's nondietary exposure to chlorpyrifos associated with toys and other sorbant surfaces for a period of 1 week following application appear to be of public health concern, and studies of actual childhood exposure from this pathway are warranted in the home environment. The above information should be used to determine if current procedures for postapplication re-entry are sufficient and to evaluate the need for procedures to store frequently used household toys, pillows, and other sorbant objects during insecticidal application.

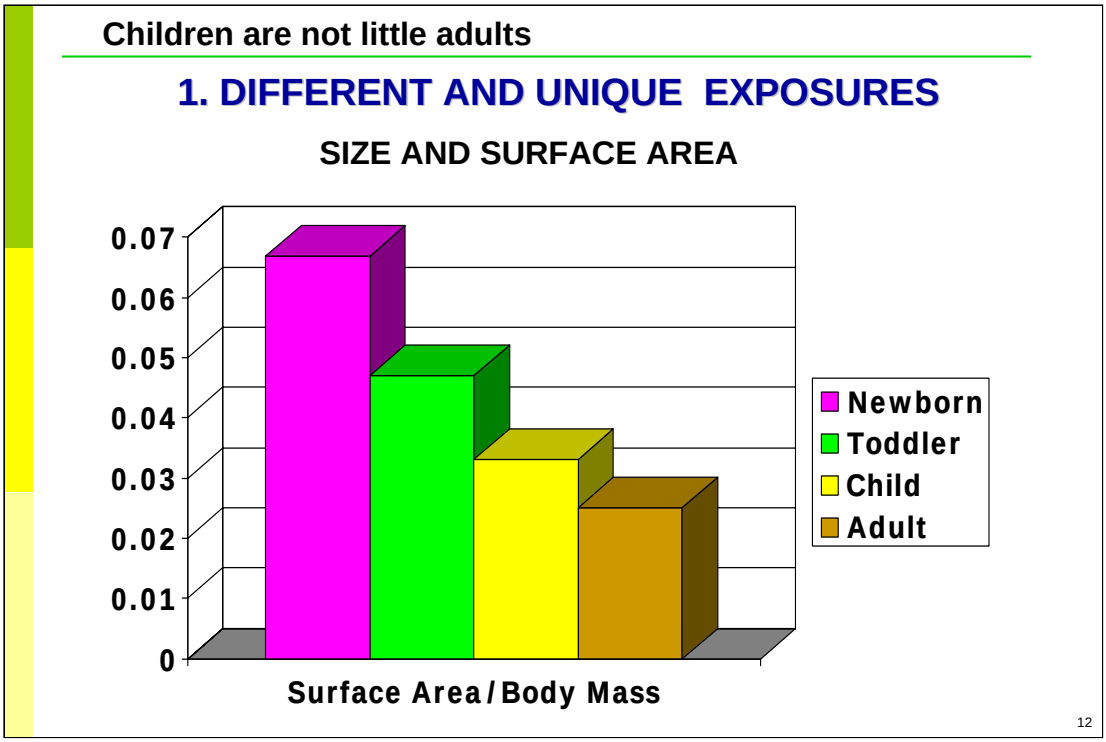
Children are not little adults

1. DIFFERENT AND UNIQUE EXPOSURES

STATURE AND BREATHING ZONES

WHO

This image from WHO shows how children inhabit a different zone from that of the adult standing in the background. Note the small girl with her fingers in the mouth and her baby "captive" in the cot.



This difference in size and proportion means that dermal exposures may be greater. Except for premature infants and newborns, children's skin presents the same barrier to dermal exposures as that of adults, but there is more of it on a surface area to volume basis. Babies have a surface area to volume ratio three times that of adults and in toddlers the ratio is twice that of adults. Also, children tend to have more skin exposed and more cuts, abrasions and rashes than adults; this could easily lead to increased dermal absorption as a proportion of body weight.

Refs:

•Reed. Principles of drugs. In: Behrman RE et al. eds. *Nelson Textbook of Pediatrics, 16th ed.* Philadelphia, WB Saunders Co, 2000.

•Image derived from information in: Selevan, Identifying critical windows of exposure for children's health. *Environ Health Perspect,* 2000, 108(Suppl 3):54.

Children are not little adults

1. DIFFERENT AND UNIQUE EXPOSURES

CHILDREN / ADOLESCENTS DO NOT RECOGNIZE DANGER

- **Pre-ambulatory children are unable to remove themselves from danger**
- **Pre-reading children cannot read warning signs & labels**
- **Pre-adolescent / adolescent children may take unreasonable risks due to cognitive immaturity and "risk-taking" behaviours**

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<<NOTE TO USER: Insert here a regionally appropriate picture of a child doing something dangerous despite an obvious warning label. >>

Children are often exposed to dangerous chemicals or situations in which injury can occur and are unable or unwilling to respond with appropriate caution because of cognitive immaturity.

Adolescents are known to exhibit risk-taking behaviour even if cognitively they are aware that the behaviour is dangerous (Dr Irena Buka, Director of Paediatric Environmental Health Specialty Unit, Misericordia Children's Health Centre, personal communication).

<<READ SLIDE.>>

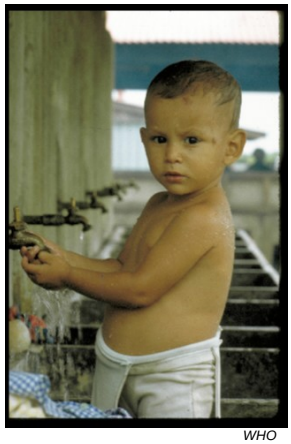
Children are not little adults

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



WHO

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Children have a dynamic physiology that is not only turned up to “high” because of growth demands, but also vulnerable to damage during differentiation and maturation of organs and systems.

•Their needs for energy, water and oxygen are higher, because they go through an intense anabolic process.

•Absorption is different and frequently increased because children are anabolic and active. They are geared to absorb nutrients very efficiently. This is exemplified most classically by lead. Lead follows calcium, which is essential for skeletal and cellular growth. A toddler will absorb between 40 and 70% of a given ingested dose of lead, whereas a non-pregnant adult will absorb from 5–20%. Nutritional deficiencies, particularly anaemia, which is common in rapidly growing children, will increase lead absorption.

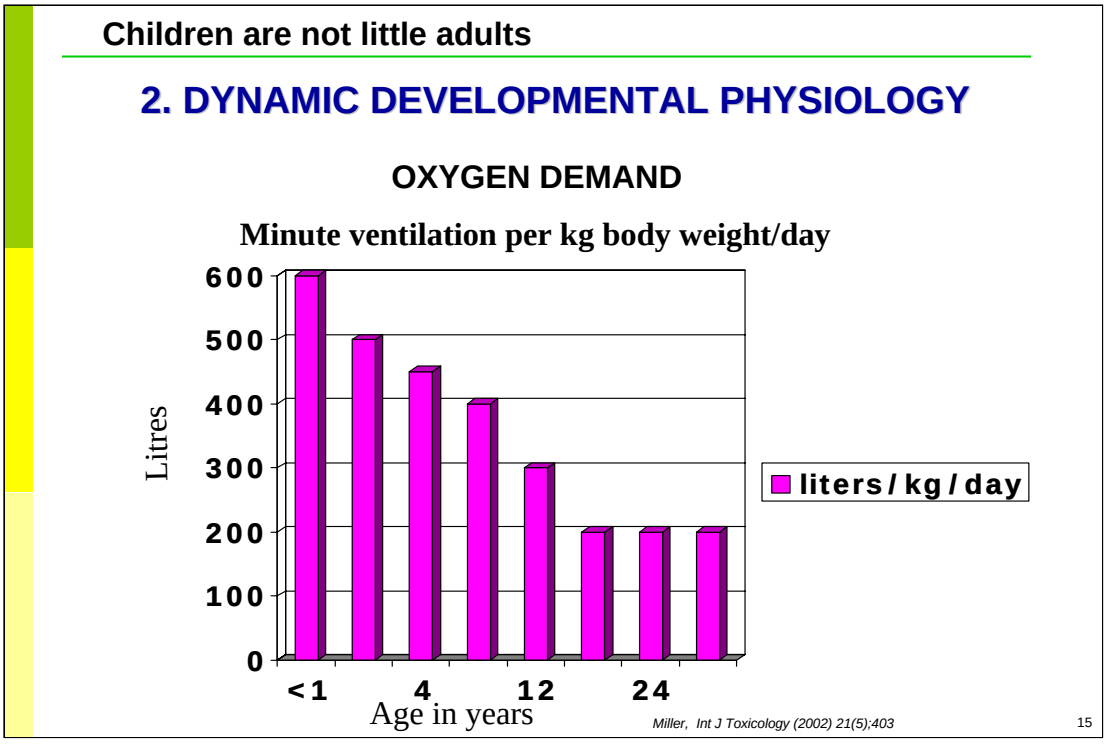
•Some xenobiotics are dangerous as ingested and need to be detoxified by metabolism. Others are not dangerous when ingested but become dangerous when metabolized. Whatever the type of xenobiotic, these processes are likely to be different in children, but unfortunately not in predictable ways. Particularly during gestation and in the first 6–12 months of life, important metabolic pathways such as cytochrome P450 systems and glutathione conjugation are significantly less efficient than later in life. Most known toxicants are detoxified in the body, so immaturity of these systems increases the duration of residence and amount of any given internal dose.

•Distribution is different from that in adults and varies with age. For example, the blood–brain barrier is not fully developed for the first 36 months of life, so substances such as lead readily cross into the CNS.

•Elimination may be decreased in early postnatal life. For example the glomerular filtration rate (GFR) of newborns is less that 40% of that of adults. Premature infants may have only 5% of the adult GFR.

All of these physiological processes are likely to be different in children from those in adults, but unfortunately not in predictable ways.

Finally, children’s systems continue to grow, mature and change through adolescence. If disrupted during critical periods, damage may be severe and lifelong. Environmental hazards may operate to harm a developmentally dynamic child by mechanisms that do not operate in the adult.



Children breathe more air per kg of body weight than adults at rest, as shown here. An infant has three times the minute ventilation of an adult and a 6-year-old has double. Children also tend to be more physically active than adults. It is clear therefore, that environmental toxicants found in the air, both indoors and outdoors, will be delivered to children at higher internal doses than to adults. These toxicants include ozone, oxides of nitrogen, particulate matter, lead, mercury and other air toxins as well as moulds, VOCs, etc.

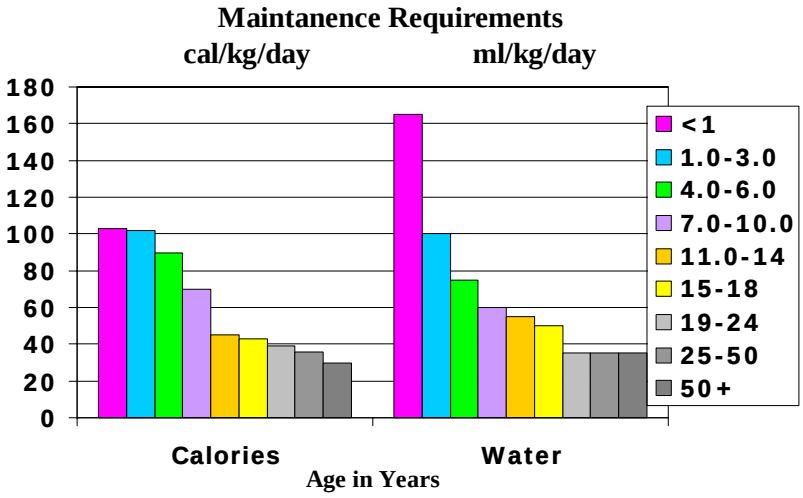
Ref: Miller. Differences between children and adults: implications for risk assessment at California EPA. *Int J Toxicol,* 2002, 21:403 (review).

The California legislature enacted a law requiring the California Environmental Protection Agency (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA) to evaluate whether our risk assessment methodologies are adequately protective of infants and children. In addition both OEHHA and the California Air Resources Board must examine whether the Ambient Air Quality Standards set for criteria air pollutants and the health values developed for air toxins are adequately protective of infants and children. We have initiated a program to look at potential differences in response to toxicants between children and adults. We are evaluating this issue from the perspective of exposure differences as well as toxicokinetic and toxicodynamic differences between children and adults. Data on specific chemicals are rather limited. As a result, we will be pooling information to determine whether there are generic differences between children and adults that may be applicable to risk assessment in general or to risk assessment of specific classes of compounds. This paper discusses the rationale for approaching the issue of determining whether our risk assessment methods are adequate for infants and children and includes a discussion of some of the available information on both qualitative and quantitative differences in response to toxicants between children and adults or immature and mature laboratory animals. We provide examples of differences between children and adults in absorption, metabolism, and excretion of toxicants as well as qualitative differences in toxic response.

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

CALORIE AND WATER NEEDS



16

Oral exposures are also likely to be greater in children.

Children are anabolic and actively building their bodies. They need more calories and more water per unit of body weight than adults. Therefore, toxicants that are carried in food will be delivered at 2–3 times higher rates in children than in adults and those in water will be delivered at 5–7 times the adult rate.

Children also tend to have a restricted diet with a higher proportion of fruits and vegetables at young ages, so that pollutants such as pesticides present in these foods are likely to be delivered in higher quantities to children.

<<NOTE TO USER: diets vary regionally and ethnically, so special mention of children's diets may need to be modified.>>

Refs:

Image derived from information in:

•Johnson. *The Johns Hopkins Hospital The Harriet Lane Handbook, 13th ed.* Mosby: St. Louis, 1993.

•Miller. Differences between children and adults: Implications for risk assessment at California EPA. *Int J Toxicology*, 2002, 21:403.

Children are not little adults

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)

17

<<READ SLIDE>>

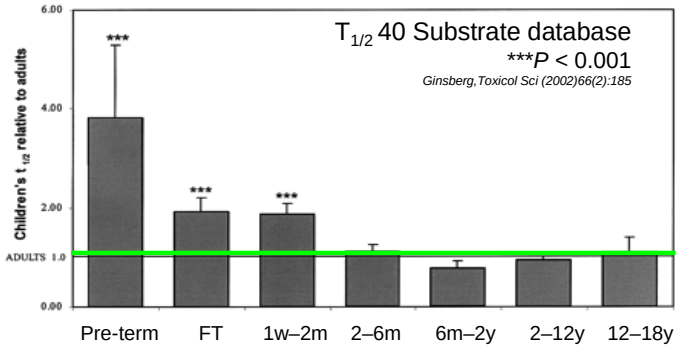
Ref:

•*ATSDR Case study on lead* (www.atsdr.cdc.gov/HEC/CSEM/lead/index.html).

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

LESSONS LEARNED FROM PHARMACEUTICALS



- **In the aggregate, slower elimination in the very young**
- **No statistical difference after 2 months**
- **Children's PK Database** *(www.clarku.edu/faculty/dhattis)*

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We know a lot about how chemicals are metabolized (or biotransformed) by children from pharmaceutical data — illustrated by the next three slides. A relatively new database is available on the web site of Clark University/Conn Department of Public Health and sponsored by USEPA. It is a rich source of pharmacokinetic information specifically developed to look at differences between children and adults with the setting of regulatory limits in mind. This graph is a composite assessment of 40 drugs for which there are complete data across these age categories. Not surprisingly, there are highly significant differences in average half-life showing slower elimination in the very young than in adults (depicted by the green line).

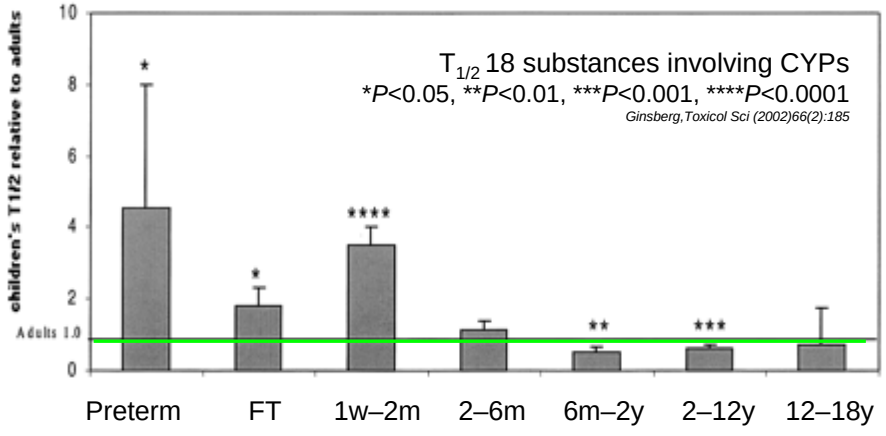
Figure: Ginsberg. Evaluation of child/adult pharmacokinetic differences from a database derived from the Therapeutic Drug Literature. *Toxicol Sci,* 2002, 66:185. *Used with copyright permission of Toxicological Sciences*

Pharmacokinetics (PK) of xenobiotics can differ widely between children and adults due to physiological differences and the immaturity of enzyme systems and clearance mechanisms. This makes extrapolation of adult dosimetry estimates to children uncertain, especially at early postnatal ages. While there are few PK data for environmental toxicants in children, there is a wealth of such data for therapeutic drugs. Using published literature, a Children's PK Database has been compiled which compares PK parameters between children and adults for 45 drugs. This has enabled comparison of child and adult PK function across a number of cytochrome P450 (CYP) pathways, as well as certain Phase II conjugation reactions and renal elimination. These comparisons indicate that premature and full-term neonates tend to have 3 to 9 times longer half-life than adults for the drugs included in the database. This difference disappears by 2–6 months of age. Beyond this age, half-life can be shorter than in adults for specific drugs and pathways. The range of neonate/adult half-life ratios exceeds the 3.16-fold factor commonly ascribed to interindividual PK variability. Thus, this uncertainty factor may not be adequate for certain chemicals in the early postnatal period. The current findings present a PK developmental profile that is relevant to environmental toxicants metabolized and cleared by the pathways represented in the current database. The manner in which this PK information can be applied to the risk assessment of children includes several different approaches: qualitative (e.g. enhanced discussion of uncertainties), semiquantitative (age group-specific adjustment factors), and quantitative (estimation of internal dosimetry in children via physiologically based PK modelling).

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

LESSONS LEARNED FROM PHARMACEUTICALS



- **More differences for substances predominantly metabolized by P450 enzymes in liver**

19

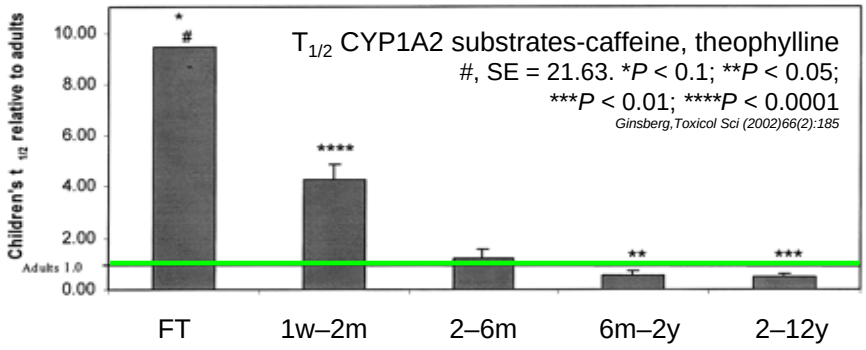
When the authors looked at substrates metabolized in the liver by P450 enzymes by age they found even more differences. Not only was elimination slower in the infants, but more rapid elimination was seen in children aged from 6 months to 12 years than adults. This provides an important reminder that not all ages of children are alike, and children in some cases, and at some stages, may be able to eliminate xenobiotics more efficiently than adults!

Figure: Ginsberg. Evaluation of child/adult pharmacokinetic differences from a database derived from the therapeutic drug literature. *Toxicol Sci,* 2002, 66:185.

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

LESSONS LEARNED FROM PHARMACEUTICALS



- **High variability even for closely related drugs**
- **Neonate/adult difference for caffeine 13X greater than for theophylline**

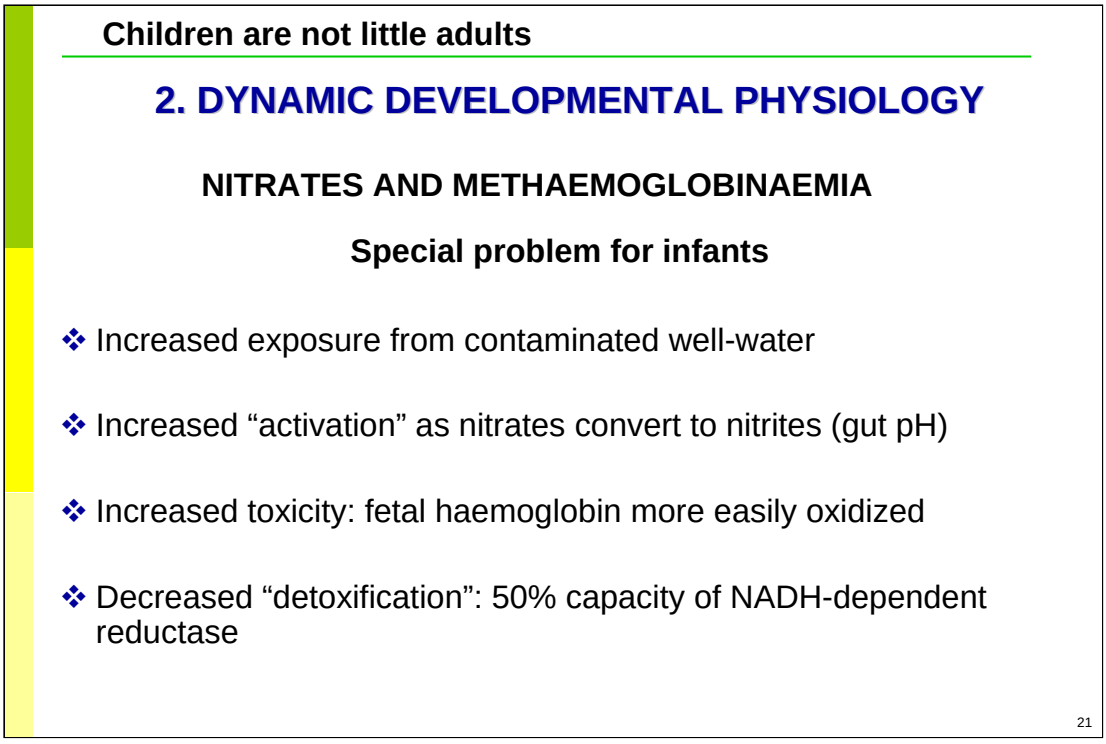
Generalizations are not possible!

20

But here is the ultimate message. Although, in general, infants eliminate pharmaceuticals more slowly than adults and older children may eliminate drugs more rapidly than adults, there is very high variability even between closely related drugs that share the same metabolic pathways. For example, in the comparison of the half-life of caffeine in neonates and adults, the difference in half-life was 13X greater than the difference between neonates and adults for theophylline. Generalizations are not possible — and the authors concluded that the standard safety factors used to account for age differences in pharmacokinetic models may be inadequate to protect young infants.

It is important to remember that, when xenobiotics require metabolic "activation" before they become toxic, this higher metabolic capacity in the older children may make them more susceptible to toxicants than are adults and young infants.

Figure: Ginsberg, Evaluation of child/adult pharmacokinetic differences from a database derived from the therapeutic drug literature. *Toxicol Sci,* 2002, 66:185.



Nitrate is an example of an environmental contaminant that is gaining importance because of increasing agricultural run-off and pollution of groundwater in many locations.

Nitrates in water — the highest exposure to water occurs in babies aged less than 6 months who are not breastfed, because they consume more water per kg body weight than adults.

Nitrates must be activated to nitrites before they become dangerous — this is more efficiently accomplished in newborns because they have a higher pH in their gastrointestinal tract.

Nitrites oxidize haemoglobin from ferrous to ferric and make it incapable of carrying oxygen. Fetal haemoglobin, normally present in young infants, is much more easily oxidized than adult haemoglobin.

Detoxification is less efficient in babies because they possess half of the detoxification capacity of one of the two enzyme systems that can repair methaemoglobin.

This example shows not only how exposures may be different, but also how metabolic immaturity may increase the harm done by an environmental chemical.

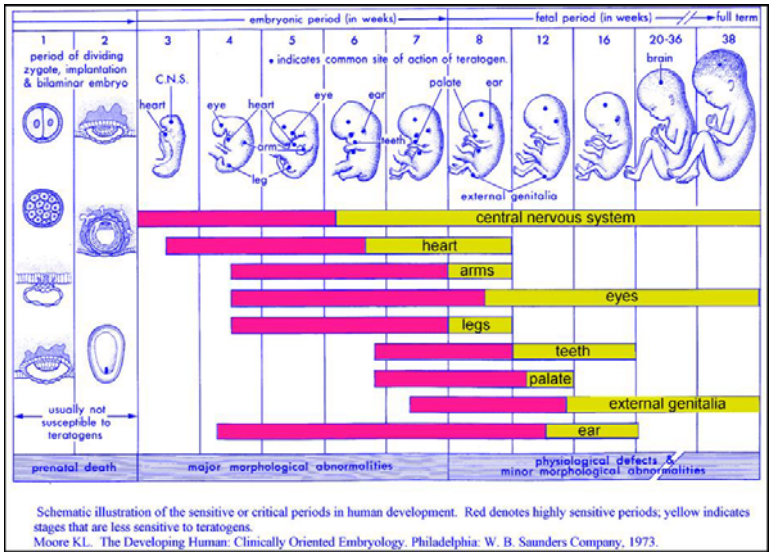
NOTE: Exclusive breastfeeding of small infants for the first 6 months eliminates this threat from nitrates in drinking water.

Ref: ATSDR Case study on nitrite/nitrates
(www.atsdr.cdc.gov/HEC/CSEM/nitrate/index.html).

Children are not little adults

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.
Moore KL. The Developing Human: Clinically Oriented Embryology. Philadelphia: W. B. Saunders Company, 1973.

Moore, Elsevier Inc, 1973

22

Physiological differences manifest in more ways than immature metabolic pathways. Because important systems are still differentiating and growing, children have unique susceptibilities compared to adults — and critical time windows in those susceptibilities.

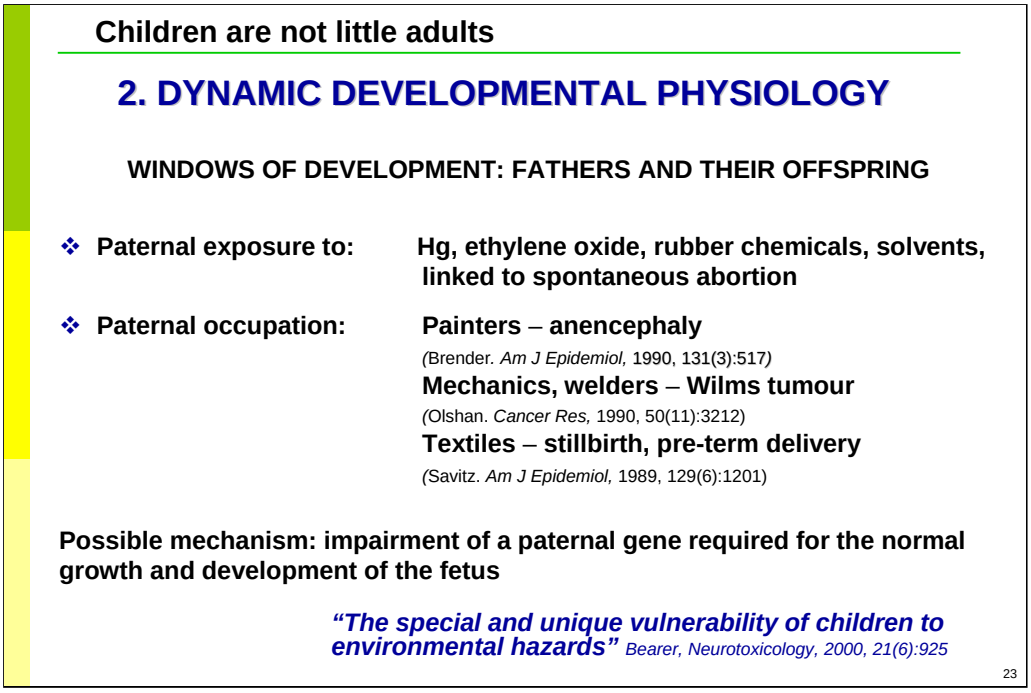
- •Preconception
- •Gestation
  - – thalidomide, DES
  - – ionizing radiation
  - – methylmercury, Pb
- •Postnatal
  - – second-hand tobacco smoke
  - – lead.

There has been an explosion of knowledge about development in the past decade or so, and it is hard to remember that it was only about 50 years ago that the discovery was made that the fetus is vulnerable to exposures. The phocomelia epidemic resulting from use of thalidomide in pregnancy was an early and dramatic example of the ability of chemicals to cross the placenta and damage the fetus. Additionally, thalidomide administered during a small, 4-day window between gestational days 20 and 24, may increase the risk of autism *(Stromland, 1994).* More than one system can be susceptible and different pathology may occur depending upon the dose and timing of exposure.

Now we know that other exposures during gestation can harm systems, and some are listed here. We also know that preconception exposure of either parent can cause harm to children, as well as postnatal exposures.

<<NOTES TO USER: It is important to point out the different responses to insults shown on the bottom bar of the figure. Significant insult during the embryonic phase will result in pregnancy loss (first 2 weeks) or major organ malformation. During the fetal stage, damage is more subtle and related to system dysfunction.>>

Ref: Stromland. Autism in thalidomide embryopathy: a population study. *Developmental Medicine & Child Neurology,* 1994, 36:351.
Of a population of 100 Swedish thalidomide embryopathy cases, at least four met full criteria for DSM-III-R autistic disorder and ICD-10 childhood autism. Thalidomide embryopathy of the kind encountered in these cases affects fetal development early in pregnancy, probably on days 20 to 24 after conception. It is argued that the possible association of thalidomide embryopathy with autism may shed some light on the issue of which neural circuitries may be involved in autism pathogenesis.



Preconception paternal exposures are now increasingly recognized as important to the health and development of the fetus.

Such exposures may increase the chance of certain diseases or adverse pregnancy outcomes as seen in the offspring. This is supported by research in animals and may well have a genetic or epigenetic mechanism.

<<READ SLIDE.>>

<<NOTE TO USER: you may want to stress exposures/occupations that are regionally specific if there are data to support prenatal or preconception effects.>>

Refs:

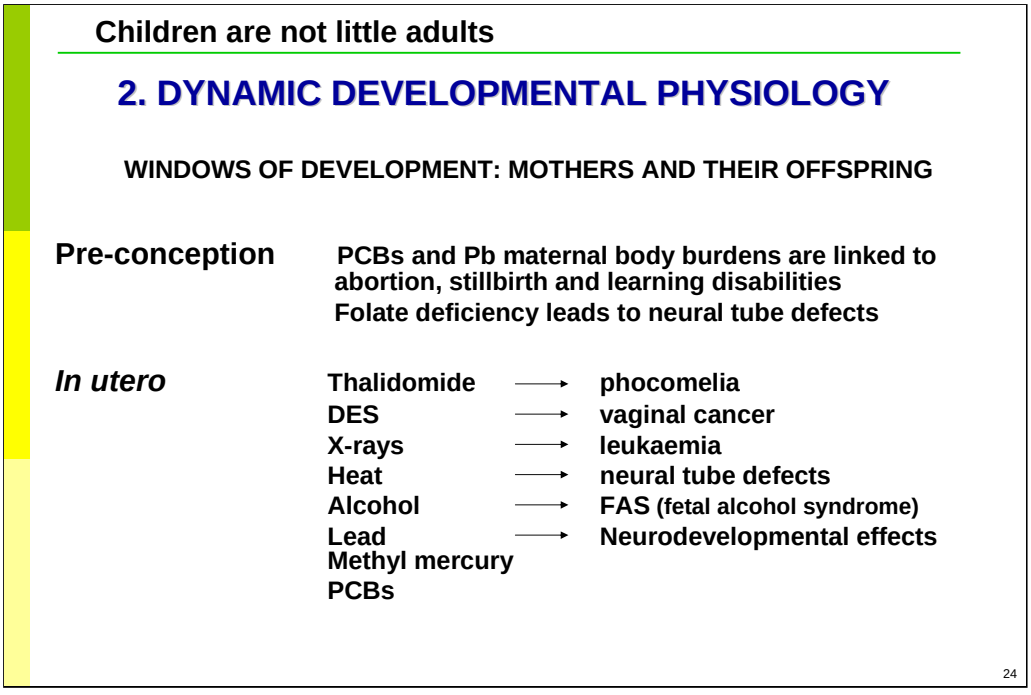
•Bearer. The special and unique vulnerability of children to environmental hazards. *Neurotoxicology*, 2000, 21:925.

•Brender. Paternal occupation and anencephaly. *Am J Epidemiol*, 1990, 131:517.

•Olshan. Wilms' tumor and paternal occupation. *Cancer Res*, 1990, 50:3212.

A case–control study was conducted to examine the relationship between Wilms' tumour and paternal occupational exposures. The case group consisted of 200 children diagnosed as having Wilms' tumour who were registered at selected National Wilms' Tumour Study institutions during the period 1 June, 1984, to 31 May, 1986. Disease-free controls were matched to each case using a random digit dialling procedure. The parents of cases and controls completed a self-administered questionnaire. There was no consistent pattern of increased risk for paternal occupational exposure to hydrocarbons or lead found in this study. However, certain paternal occupations were found to have an elevated odds ratio (OR) of Wilms' tumour, including vehicle mechanics, auto body repairmen, and welders. Offspring of fathers who were auto mechanics had a 4- to 7-fold increased risk of Wilms' tumour for all three time periods. The largest increased odds ratio for auto mechanics was in the preconception period [OR = 7.58; 95% confidence interval (CI) = 0.90–63.9]. Welders had a 4- to 8-fold increased odds ratio, with the strongest association during pregnancy (OR = 8.22; CI = 0.95–71.3). Although chance cannot be excluded as a possible explanation, association of Wilms' tumour with these occupations has been reported in previous studies. Further study is needed to provide data on the specific occupational exposures involved.

•Savitz. Effect of parents' occupational exposures on risk of stillbirth, preterm delivery, and small-for-gestational-age infants. *Am J Epidemiol,* 1989, 129:1201.



Mothers' exposures both prior to conception and during pregnancy are associated with a variety of outcomes including spontaneous abortion, stillbirth or neonatal death, poor intrauterine growth, major birth defects and functional deficits.

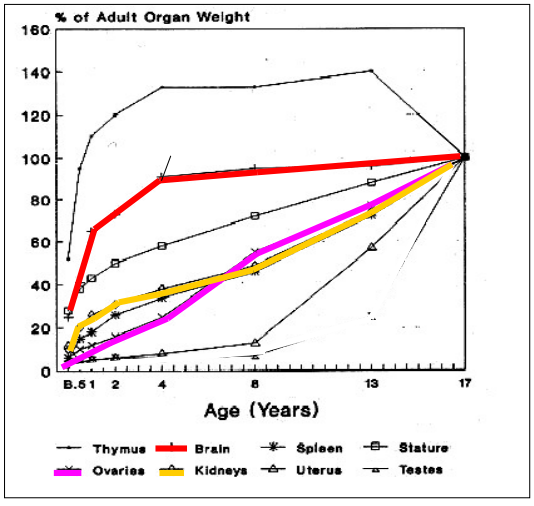
<<READ SLIDE.>>

<<NOTE TO USER: you may want to stress exposures/occupations that are regionally specific if there are data to support prenatal or preconception effects.>>

Children are not little adults

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

Altman eds, FASEB, 1962

And we know that growth does not stop at birth, but continues through adolescence. This is not only physical growth, but also the maturation and continued differentiation of physiological functions. This graph shows the dramatic growth of major organs as well as their very different trajectories. Not only do the organs grow, but their function also matures and modifies at different life stages, until the end of adolescence.

Figure: Altman eds. *Growth - including reproduction and morphological development.* Washington, DC, FASEB (Federation of American Societies for Experimental Biology), 1962. *Used with copyright permission.*

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

NEURODEVELOPMENT: CONTINUES THROUGH PUBERTY!

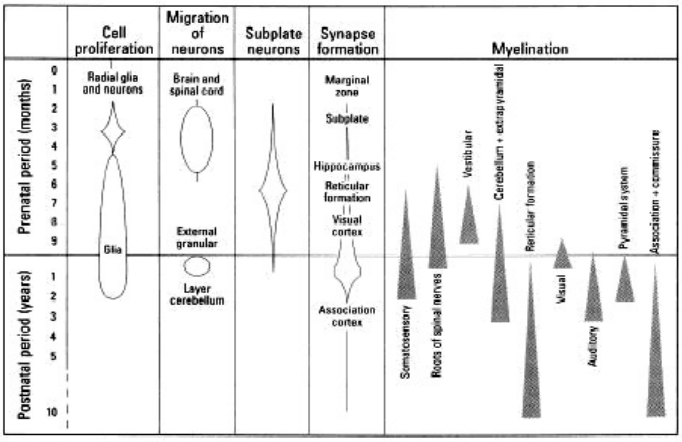


Figure 2. Comparison of timelines for developmental processes in humans. The prenatal period is scaled in months and the postnatal development is scaled in years. Adapted from Herschkowitz et al. (*16*) and reprinted with permission of Hippokrates Verlag GmbH.

- **Growth 4–17 yrs in fibre tracts for motor and speech**
- **Activity alters architecture**
- **Adolescence extensive elimination of some synapses**
- **Redistribution of neurotransmitters**

Rice,EHP, (2000) 108 (3), 511

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As an example, let's look at the central nervous system. This diagram shows prenatal and postnatal development in the upper and lower sections, respectively. You can see that neurodevelopment continues through the second decade with significant changes in myelinization, synaptogenesis and neurotransmitter distribution throughout the maturation phase.

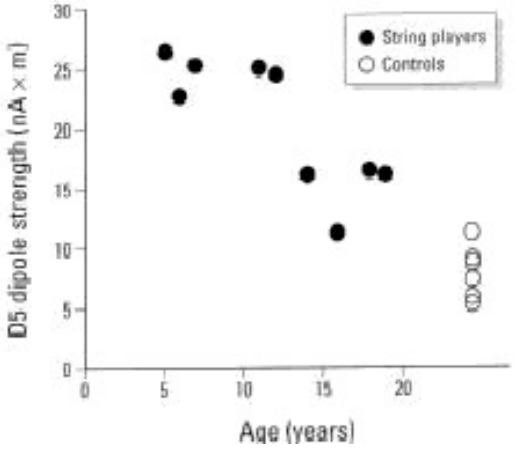
Figure: Rice. Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models. *Environmental Health Perspectives,* 2000, 108 (Suppl 3): 511. *Reproduced with permission from Environmental Health Perspective*

Vulnerable periods during the development of the nervous system are sensitive to environmental insults because they are dependent on the temporal and regional emergence of critical developmental processes (i.e. proliferation, migration, differentiation, synaptogenesis, myelination, and apoptosis). Evidence from numerous sources demonstrates that neural development extends from the embryonic period through adolescence. In general, the sequence of events is comparable among species, although the time scales are considerably different. Developmental exposure of animals or humans to numerous agents (e.g. X-ray irradiation, methylazoxymethanol, ethanol, lead, methyl mercury, or chlorpyrifos) demonstrates that interference with one or more of these developmental processes can lead to developmental neurotoxicity. Different behavioural domains (e.g. sensory, motor, and various cognitive functions) are subserved by different brain areas. Although there are important differences between the rodent and human brain, analogous structures can be identified. Moreover, the ontogeny of specific behaviours can be used to draw inferences regarding the maturation of specific brain structures or neural circuits in rodents and primates, including humans. Furthermore, various clinical disorders in humans (e.g. schizophrenia, dyslexia, epilepsy, and autism) may also be the result of interference with normal ontogeny of developmental processes in the nervous system. Of critical concern is the possibility that developmental exposure to neurotoxicants may result in an acceleration of age-related decline in function. This concern is compounded by the fact that developmental neurotoxicity that results in small effects can have a profound societal impact when amortized across the entire population and across the lifespan of humans.

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

NEURODEVELOPMENT: CONTINUES THROUGH PUBERTY!



Rice. Critical periods of vulnerability for the developing nervous system. *EHP*, 2000, 108 (3): 520

An example: activity alters brain architecture

- **Centre of cortical responsive to tactile stimulation of the 5th finger, left hand**
  - Violin players vs non-players
  - Correlated with age of onset, not amount of practice

Toxic exposures can alter brain architecture also!

27

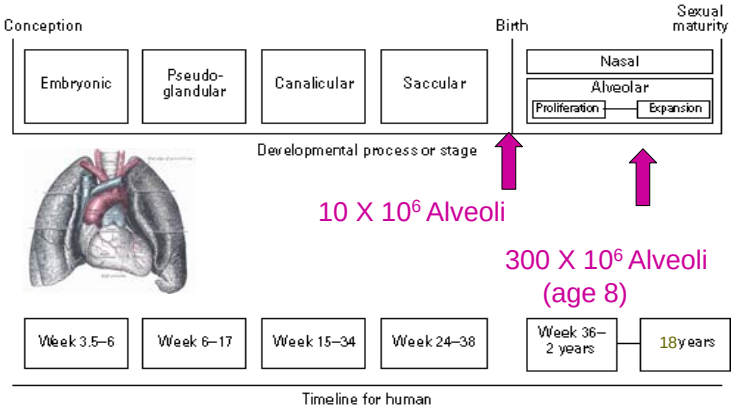
The way the brain develops is determined in part by the interaction an individual has with the environment. This slide shows the size of the area in the cortex responsive to tactile stimulation of the fifth finger on the left hand as measured by magnetic resonance imaging. Violin players showed an expansion of the cortical area devoted to the left hand area that was correlated with the age at inception of musical practice but not with the amount of practice. This is a CRITICAL WINDOW of development where timing not dose makes the difference! If activity can alter brain architecture, so can toxic exposures.

Figure: Rice. Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models. *Environmental Health Perspectives,* 2000, 108:520.
Reproduced with permission from Environmental Health Perspectives

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

RESPIRATORY DEVELOPMENT: CONTINUES THROUGH LINEAR GROWTH



Growth
- Tobacco smoke
- Particulates
- Ozone

Function
- Indoor air
- Ozone

Dieter,. *EHP,* 2000,108 (3): 483.

28

Like the nervous system, the respiratory system continues to grow and develop through linear growth. At birth a baby has only about 10 million alveoli, but at age 8 years, he or she has 300 million. Certain types of exposures during these growth periods are known to have adverse consequences on both structure (e.g. second-hand tobacco smoke, particulates and ozone) and function (e.g. poor indoor air quality and outdoor ozone).

Figure: Dieter. Workshop to identify critical windows of exposure for children's health: immune and respiratory systems work group summary. *Environmental Health Perspectives,* 2000, 108: 483.

Reproduced with permission from Environmental Health Perspectives.

Children are not little adults

2. DYNAMIC DEVELOPMENTAL PHYSIOLOGY

RESPIRATORY DEVELOPMENT: STUDIES SHOW

- **Deficits in pulmonary function tests**
  - **Related to exposure to particulates, oxides of nitrogen and inorganic acid vapours** (Gauderman. *Am J Respir Crit Care Med,* 2000, 162 (4): 1383)
  - **Exposure to second-hand tobacco damages pulmonary function** (Tager. *N Engl J Med,* 1983, 309 (12): 699)
- **"Dirty air stunts growth"**
  - **Study of 3000 children since 1993 showed impaired lung growth…may be linked to asthma and emphysema in adults** (Gauderman. *Am J Respir Crit Care Med* , 2000, 162 (4): 1383)

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<<READ SLIDE>>

In the fourth-grade cohort, significant deficits in growth of lung function (FEV_1, FVC, maximal mid-expiratory flow [MMEF], and FEF_{75}) were associated with exposure to particles with an aerodynamic diameter of less than 10 μm (PM_{10}), $PM_{2.5}$, PM_{10}-$PM_{2.5}$, NO_2, and inorganic acid vapour ($P < 0.05$) (*Gauderman, 2000).*

In the first long-term study of air pollution's effects on children, it was shown that contaminated air stunts lung development in teenagers and the effects could extend well into adulthood *(Gauderman, 2004).*

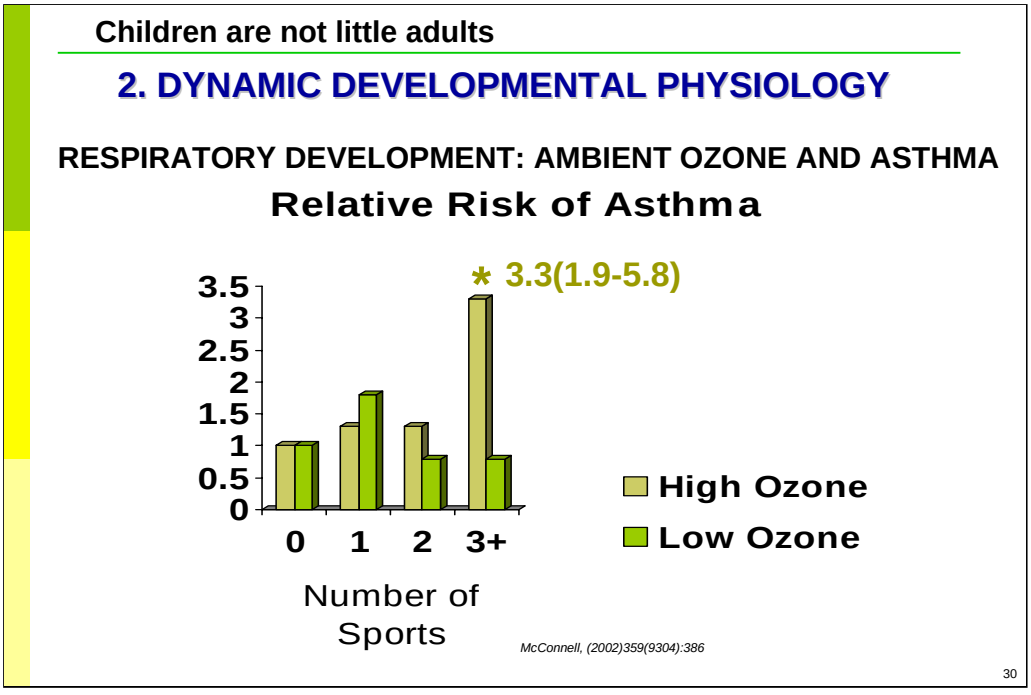
It has long been appreciated that exposure to tobacco smoke causes increased incidence of lower respiratory infection, asthma and otitis media. In this early study by Tager et al. (1983), the authors investigated the effects of maternal cigarette smoking on pulmonary function in a cohort of children and adolescents observed prospectively for 7 years. A multivariate analysis revealed that after correction for previous forced expiratory volume in 1 second (FEV_1), age, height, change in height, and cigarette smoking in the child or adolescent, maternal smoking significantly lowered the expected average annual increase in FEV_1 ($P = 0.015$). On the basis of this analysis, it is estimated that if two children have the same initial FEV_1, age, height, increase in height, and personal cigarette smoking history, but the mother of one smoked throughout the child's life whereas the mother of the other did not, the difference in the change in FEV_1 over time in the exposed child, as compared with that in the unexposed child, will be approximately 28, 51, and 101 ml after 1, 2 and 5 years, respectively, or a reduction of 10.7, 9.5 and 7.0%, respectively, in the expected increase. These results suggest that passive exposure to maternal cigarette smoking may have important effects on the development of pulmonary function in children.

Refs:

•Gauderman. Association between air pollution and lung function growth in southern California children. *Am J Respir Crit Care Med,* 2000, 162:1383.

•Gauderman. The effect of air pollution on lung development from 10 to 18 years of age. *N Engl J Med,* 2004 351:1057.

•Tager. Longitudinal study of the effects of maternal smoking on pulmonary function in children. *N Engl J Med,* 1983, 309:699.



Recent studies have shown decreased growth in lung function in year-round athletic children growing up in areas with high ozone levels. Also, increased onset of asthma, as depicted in this graph, has been reported in areas with high ozone levels. The relative risk of developing asthma was three times higher for children living in areas with high ozone levels who participated in three or more sports, than in children living in areas with low ozone levels who participated in three or more sports. Although this study has not yet been replicated, it is the first prospective study to suggest a link between high levels of exposure to outdoor ozone pollution and the onset of asthma in children.

Similar examples of ongoing vulnerability and critical windows of development can be cited for other major organs and systems.

Ref:

•McConnell, Asthma in exercising children exposed to ozone: a cohort study . *Lancet,* 2002, 359:386.

Background: *Little is known about the effect of exposure to air pollution during exercise or time spent outdoors on the development of asthma. We investigated the relation between newly-diagnosed asthma and team sports in a cohort of children exposed to different concentrations and mixtures of air pollutants.* Methods: *3535 children with no history of asthma were recruited from schools in 12 communities in southern California and were followed up for up to 5 years. 265 children reported a new diagnosis of asthma during follow-up. We assessed risk of asthma in children playing team sports at study entry in six communities with high daytime ozone concentrations, six with lower concentrations, and in communities with high or low concentrations of nitrogen dioxide, particulate matter, and inorganic-acid vapour.* Findings: *In communities with high ozone concentrations, the relative risk of developing asthma in children playing three or more sports was 3.3 (95% CI 1.9–5.8), compared with children playing no sports. Sports had no effect in areas of low ozone concentration (0.8, 0.4–1.6). Time spent outside was associated with a higher incidence of asthma in areas of high ozone (1.4, 1.0–2.1), but not in areas of low ozone. Exposure to pollutants other than ozone did not alter the effect of team sports.* Interpretation: *Incidence of new diagnoses of asthma is associated with heavy exercise in communities with high concentrations of ozone, thus, air pollution and outdoor exercise could contribute to the development of asthma in children.*

Children are not little adults

3. LONGER LIFE EXPECTANCY

WHO

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

Children inherit the world WE make!

31

Children, ideally, are around longer in the world than adults.

Not only do they live longer, allowing more time in which to develop diseases with long latency, but they also have longer to live with disabilities. In addition, they inherit the world we are creating, with all its problems and promises.

So these three main characteristics of children:

1) unique and different types of exposures;

2) dynamic developmental physiology; and

3) longer life expectancy

represent the scientific reasons that children are not little adults with respect to environmental hazards. An important difference is that the unique issues of the timing of exposure with respect to critical windows enlarges on the old concept of toxicology captured in the phrase “the dose makes the poison” to become “the dose **and the timing** make the poison”.

<<NOTE TO USER: This image may be replaced with one showing a regionally appropriate baby.>>

Children are not little adults

3. LONGER LIFE EXPECTANCY

Two examples:

- **Asbestos exposure in children and cancer many years after it**
- **Childhood exposure to lead and its relationship with adult hypertension and mortality**

32

•**Asbestos exposure in children and cancer many years after it:** *Asbestos is a fibrous substance classified as a human carcinogen. Asbestos fibres might enter the body through inhalation or ingestion. Because the body cannot break down or eliminate asbestos fibres once they enter the lungs or body tissues, the fibres become trapped, causing serious health problems. Exposure to asbestos can lead to signs of lung abnormalities (pleural plaques) or to scarring of the lung tissues (asbestosis) and two types of cancer (lung cancer and mesothelioma). The risk for asbestos-related disease depends on many factors, including type of asbestos fibre, level of exposure, duration of exposure. The latency period for these diseases ranges from 10 years to 30 years.* The Agency for Toxic Substances and Disease Registry (ATSDR) was asked by the US *Environmental Protection Agency (EPA) to determine the extent of asbestos-related exposures in the Libby area and to address community concerns. Notes taken from: The Agency for Toxic Substances and Disease Registry. The Community Environmental Health Project in Libby, Montana. Atlanta, GA: Agency for Toxic Substances and Disease Registry. Available at: www.atsdr.cdc.gov/HEC/HSPH/vol12no1.pdf*

• **Childhood lead exposure and its relationship with adult hypertension and mortality**

Refs:

•McDonald. Lead's legacy? Early and late mortality of 454 lead-poisoned children. *Arch Environ Health,* 1996, 51:116.

A series of 454 paediatric hospital patients who were diagnosed with lead poisoning between 1923 and 1966 were traced through 1991 to examine possible mortality effects. Numbers of observed deaths were compared with those expected, based on the rates of the US population. Eighty-six deaths were observed (O/E = 1.7, 95% confidence interval (95% CI) = 1.4–2.2), of which 17 were attributed to lead poisoning. Mortality from all cardiovascular disease was elevated (O/E = 2.1, 95% CI = 1.3–3.2), and cerebrovascular deaths were particularly common among women (O/E = 5.5, 95% CI = 1.1–15.9). Among men, 2 deaths resulted from pancreatic cancer (O/E = 10.2, 95% CI = 1.1–36.2), and 2 deaths resulted from non-Hodgkin's lymphoma (O/E = 13.0, 95% CI = 1.5–46.9). Chronic nephritis was not a significant cause of death. Despite limitations in the data, the pattern of mortality suggests that effects of lead poisoning in childhood may persist throughout life and may be experienced differently by men and women.

•Hu. A 50-year follow-up of childhood plumbism. Hypertension, renal function, and hemoglobin levels among survivors. *Am J Dis Child,* 1991, 145:681.

A group of 192 subjects with well-documented lead poisoning in 1930 to 1942 were identified in this pilot study. Thirty-five of 72 survivors traced to a Boston area address and 22 age-, sex-, race-, and neighbourhood-matched controls were recruited into a clinical study. One matched subject with plumbism had grossly abnormal renal function and an elevated blood lead level of an unclear cause. Among the remaining 21 matched pairs, the risk of hypertension was significantly higher in subjects with plumbism (relative risk, 7.0; 95% confidence interval, 1.2 to 42.3). Mean adjusted creatinine clearance rates for subjects with plumbism, however, were significantly higher than those of controls and supranormal in comparison to rates predicted for sex and age. Subjects with plumbism had significantly lower hemoglobin concentrations and hematocrit readings than the controls. Blood lead and serum creatinine levels were low for both groups. These results suggest that survivors of childhood lead poisoning have an increased risk of clinically significant hypertension developing in the setting of supranormal creatinine clearance rates.

•Lustberg. Blood lead levels and mortality. *Arch Intern Med,* 2002, 162:2443.

Despite declines in blood lead levels during the past 20 years, lead exposure continues to be a public health concern. Studies have linked lead exposure with increased risk for diverse health outcomes. Few studies have evaluated the association of lead exposure and mortality in the general population. Methods: *To evaluate the association of lead exposure and mortality in the United States, we used the recently released mortality follow-up data for participants of the Second National Health and Nutrition Examination Survey, a national cross-sectional survey of the general population conducted from 1976 to 1980. Survey participants aged 30 to 74 years with blood lead measurements were followed up through December 31, 1992 (n = 4292).* Results: *After adjustment for potential confounders, individuals with baseline blood lead levels of 20 to 29 microg/dL (1.0–1.4 micromol/L) had 46% increased all-cause mortality (rate ratio [RR], 1.46; 95% confidence interval [CI], 1.14–1.86), 39% increased circulatory mortality (RR, 1.39; 95% CI, 1.01–1.91), and 68% increased cancer mortality (RR, 1.68; 95% CI, 1.02–2.78) compared with those with blood lead levels of less than 10 microg/dL (<0.5 micromol/L). All-cause mortality for those with blood lead levels of 10 to 19 microg/dL (0.5–0.9 micromol/L) was intermediately increased and not statistically significant (RR, 1.17; 95% CI, 0.90–1.52).* Conclusions: *Individuals with blood lead levels of 20 to 29 micro g/dL in 1976 to 1980 (15% of the US population at that time) experienced significantly increased all-cause, circulatory, and cardiovascular mortality from 1976 through 1992. Thus, we strongly encourage efforts to reduce lead exposure for occupationally exposed workers and the 1.7 million Americans with blood lead levels of at least 20 micro g/dL (> or = 1.0 micromol/L).*

Children are not little adults

4. POLITICALLY POWERLESS

by Ceppi and Corra

- **No political voice**
- **Advocacy by health sector**
- **Environmental laws and regulations**
  - Local
  - National
  - International

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The fourth characteristic category takes us into the realm of laws, policy and advocacy.

•Children have no political voice.

•They are defenceless in a world that adults have created for them and vulnerable to environmental hazards.

•Children do not vote.

There's a long tradition of advocacy in paediatrics with respect to abuse, neglect, toy and product safety. In the 1990s paediatricians and other professionals (especially in the Northern countries) have begun to advocate changes in laws and regulations which will specifically protect children from environmental harm. There are a variety of mechanisms either proposed or in place designed to improve children's environmental health. They range from very local initiatives, rules and laws to international treaties and resolutions. It is critical that practitioners of children's environmental health become and stay politically active, in all countries.

Children are not little adults

CHILDREN ARE NOT LITTLE ADULTS

Raphael, National Gallery of Art, Washington, DC

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

34

<<NOTE TO USER: Replace with culturally/regionally appropriate image which illustrates the physical differences between babies and adults.>>

In this presentation we have described four dimensions along which children are not little adults with respect to environmental exposures.

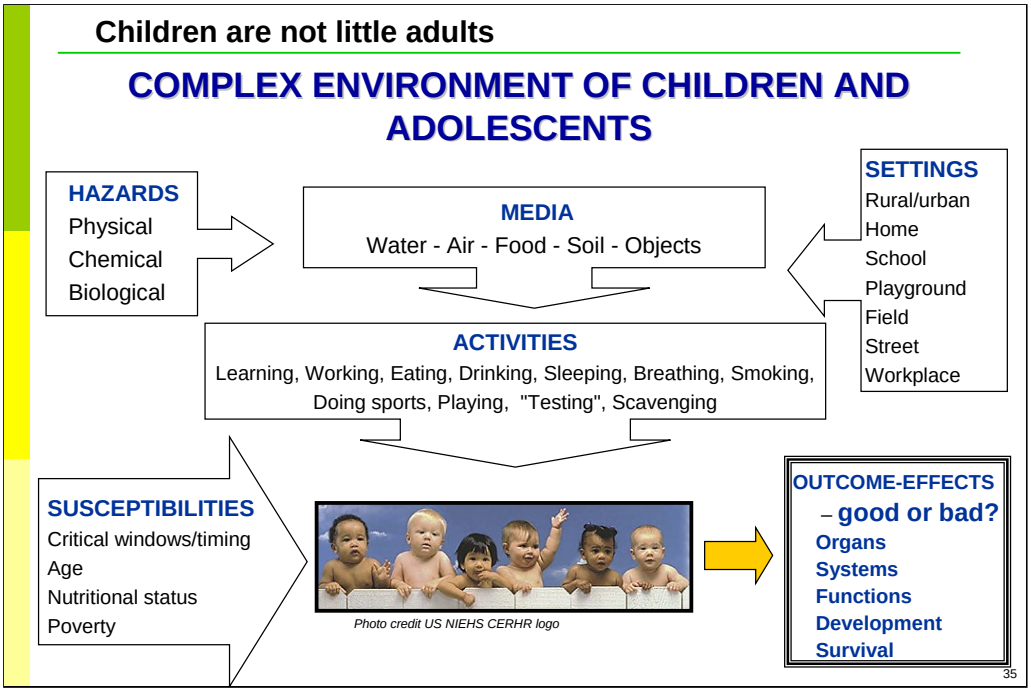
These include:

1) their different, unique and often increased exposures to chemical, biological and physical environmental hazards;

2) their dynamic developmental physiology, which includes high energy demands for growth, variable and changing metabolic and elimination pathways and critical windows of development from conception through adolescence;

3) their longer life expectancy; and

4) their political powerlessness.



In this summary slide, we see the complexity of the issues related to children's environmental health. Hazards (physical, chemical, biological – in many cases favoured by social factors) are introduced into environmental media (water, air, food, soil, objects and toys) with variable efficiency in different settings (urban and rural: home, school, field, playground, street and workplace). A child's activities bring him or her into contact with these hazards.

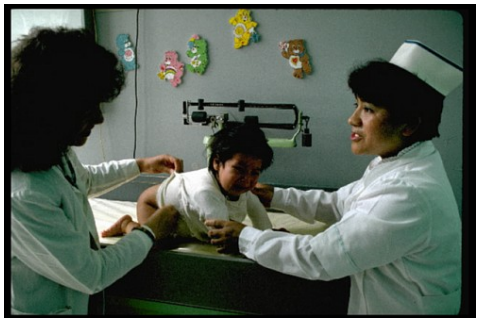
<<READ SLIDE.>>

Depending upon the individual susceptibility of the child based upon age, general health and social supports, the exposure may cause harm ranging from subtle changes in function to death.

Children's environmental health is the field which synthesizes these complexities and attempts to make fundamental changes to improve children's environments and prevent environmental illnesses.

Children are not little adults

CRITICAL ROLE OF HEALTH AND ENVIRONMENT PROFESSIONALS



WHO

- **Diagnose and treat**
- **Publish, research**
  - Sentinel cases
  - Community-based interventions
- **Educate**
  - Patients and families
  - Colleagues and students
- **Advocate**
- **Provide good role model**

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Health and environment professionals have a critical role to play in maintaining and stimulating changes that will restore and protect children's environmental health.

Although the human genome project is very important and scientifically exciting, we all know that genes express themselves within an environment and understanding gene–environment interactions is what will keep our children healthy. So, as we look to our political and personal lives to support sustainable development, we can look to our practices for ways to enhance the environmental health of our patients.

All of us can do something.

At the one-to-one patient level we can include environmental etiologies in our differential diagnoses and in our preventive advice. We can be dissatisfied with the diagnosis of "idiopathic" and look hard for potential environmental causes of disease and disability.

We can publish sentinel cases and develop and write up community-based interventions.

We can educate our patients, families, colleagues and students didactically.

Finally, we must all become vigorous advocates for the environmental health of our children and future generations. It is not enough to be an informed citizen, we need to write letters and articles, testify at hearings, approach our elected officials with educational and positive messages, avoiding "scares" and "alarmism", but provide evidence for action and clear proposals for remedial and preventive activities.

And, we must all recognize that as professionals with an understanding of both health and the environment, we are powerful role models. Our choices will be noticed: they should be thoughtful and sustainable.

To expand your information on children's environmental health, please go to the website of TEACH (Toxicity and Exposure Assessment for Children's Health), a database that contains over 1400 references to the scientific literature in this field: *cfpub.epa.gov/teach/*

Children are not little adults

We hold our future in our hands and it is our children

Poster Contest by HRIDAY with support from WHO SEARO

I end with this beautiful reminder to us from a child in India. We must recognize the risks to our children and assume our responsibilities for preventing them, because we hold our future in our hands — and it is our children.

Thank you.