TRAINING FOR THE HEALTH SECTOR

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CHILDREN AND CHEMICALS

Children's Health and the Environment

WHO Training Package for the Health Sector

World Health Organization

www.who.int/ceh

October 2011

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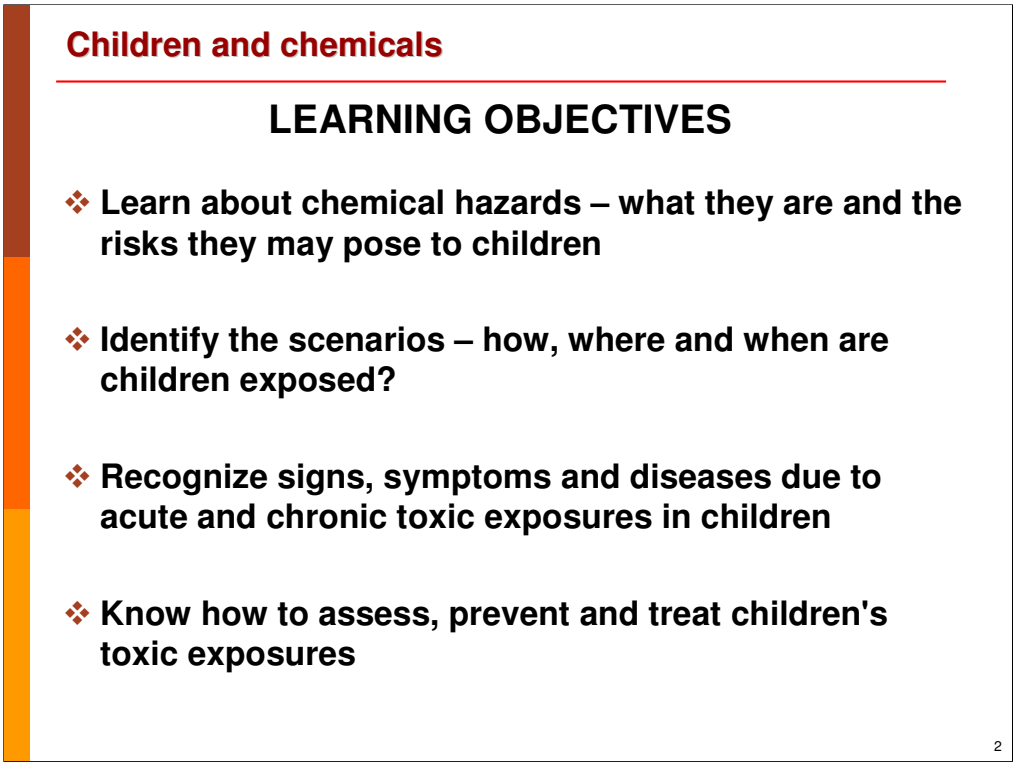
<<NOTE TO USER: Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated.>>

<<NOTE TO USER: This is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local situation in the region.>>



<<READ SLIDE>>

This presentation deals with children and chemicals – an issue of great concern for parents and communities, and also for policy-makers, that has been the subject of a number of international recommendations. Health care providers can play a key role in reducing children's exposures to chemicals.

Children and chemicals

CHEMICALS AMONG OTHER GLOBAL ENVIRONMENTAL HEALTH ISSUES

- Chemical hazards
- Air pollution - indoor and outdoor
- Household water insecurity
- Poor hygiene and sanitation
- Disease vectors
- Injuries and accidents
- Emerging issues
  - *Climate change*
  - *POPs*
  - *Ozone layer*

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At the GLOBAL level, WHO has identified six main environmental threats to children's health, in addition to the so-called "emerging issues".

All of these threats have either a strong *chemical* component or are related to the use of chemicals. These threats are as follows:

•**Chemical hazards**. Exposure to both the "old" and "new" chemicals, of anthropogenic and natural origin, present in the places where children spend time, can be dangerous (this will be the theme of the presentation).

•**Air pollution (indoor and outdoor)**. Ozone, SO2, N02, sulfate particles (a major fraction of the particle burden in urban air), carbon soot, polycyclic aromatic hydrocarbons and carbon monoxide, are some of the typical air contaminants, whose effects on children's morbidity and mortality have been clearly demonstrated. Tobacco smoke is very rich in particles and polycyclic aromatic hydrocarbons. Indoor air pollution from use of biomass fuel in developing countries is a major public health problem, as it contributes heavily to the mortality of children under 5 years.

•**Household water insecurity**. Although in developing countries the main concern is *microbiological* contamination, a number of water pollutants have a tremendous impact on public health, namely: arsenic, lead, fluoride and pesticides.

•**Poor hygiene and sanitation**. These hinder the maintenance of clean environments – the washing, cleaning and removal of chemicals, dirt and pollutants.

•**Disease vectors**. Combating malaria, dengue and other vector-borne diseases relies to a great extent on the use of pesticides, and this increases the risk of children's exposure to these products used either at home or in the context of public health campaigns

•**Injuries and accidents.** These include poisoning, the non-intentional (or intentional) injury due to toxicants (e.g. a child drinking poisonous household chemicals stored in bottles previously used for beverages).

•**EMERGING ISSUES!** These include the consideration of climate change, depletion of the ozone layer and also the potential risk posed by electromagnetic fields and by chemicals that persist in the environment (persistent organic pollutants (POPs)).

Refs:

•Goldman L, Tran N. Toxics and poverty: the impact of toxic substances on the poor in developing countries. *The World Bank,* Washington DC, 2002.

•International Agency for Research on Cancer. Chlorinated drinking-water, chlorination by-products; some other halogenated compounds; cobalt and cobalt compounds. *International Agency for Research on Cancer Monograph*, 1991, 52.

•Schwartz J. Air Pollution and Children's health. *Pediatrics*, 2004, 113(4):1037-43.

•WHO. Children's health and the environment: a global perspective. Pronczuk J, ed. *WHO*, Geneva, 2005

•WHO/UNEP. Healthy environments for healthy children. Key messages for action. *WHO*, Geneva, 2010. Available at www.who.int/ceh/publications/hehc_booklet/en/index.html – accessed May 2011.

Image: WHO

Children and chemicals

CHEMICALS ARE USED IN EVERYDAY LIFE

Benefits

- **Promote hygiene**
- **Protect crops**
- **Control vectors**

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Risks

- **Adverse health effects**
- **Unwanted pollutants in the environment**
- **Persistence**

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<<READ SLIDE>>

Chemicals are used in everyday life – they bring in numerous benefits, such as protecting human and animal health, promoting hygiene, protecting crops, controlling vectors of disease. However, chemicals may also pose risks to human and animal health. Exposures to chemicals in the micro- and macro-environments of children may cause functional and organic damage, especially during periods of vulnerability. Many become unwanted pollutants and some of these are persistent in the environment.

Ref:

•Goldman L, Tran N. Toxics and poverty: the impact of toxic substances on the poor in developing countries. *The World Bank,* Washington DC, 2002.

•WHO. Children's health and the environment: a global perspective. Pronczuk J, ed. *WHO*, Geneva, 2005

•WHO/UNEP. Healthy environments for healthy children. Key messages for action. *WHO*, Geneva, 2010. Available at www.who.int/ceh/publications/hehc_booklet/en/index.html – accessed May 2011.

Image: WHO

Children and chemicals

CHILDREN AND TOXICANTS

WHO

Acute and chronic, high and low-level exposures to chemicals in the environments of children may cause functional and organic damage, during periods of special vulnerability

"Children are not little adults"…

Informed health care providers play a key role in preventing and managing diseases

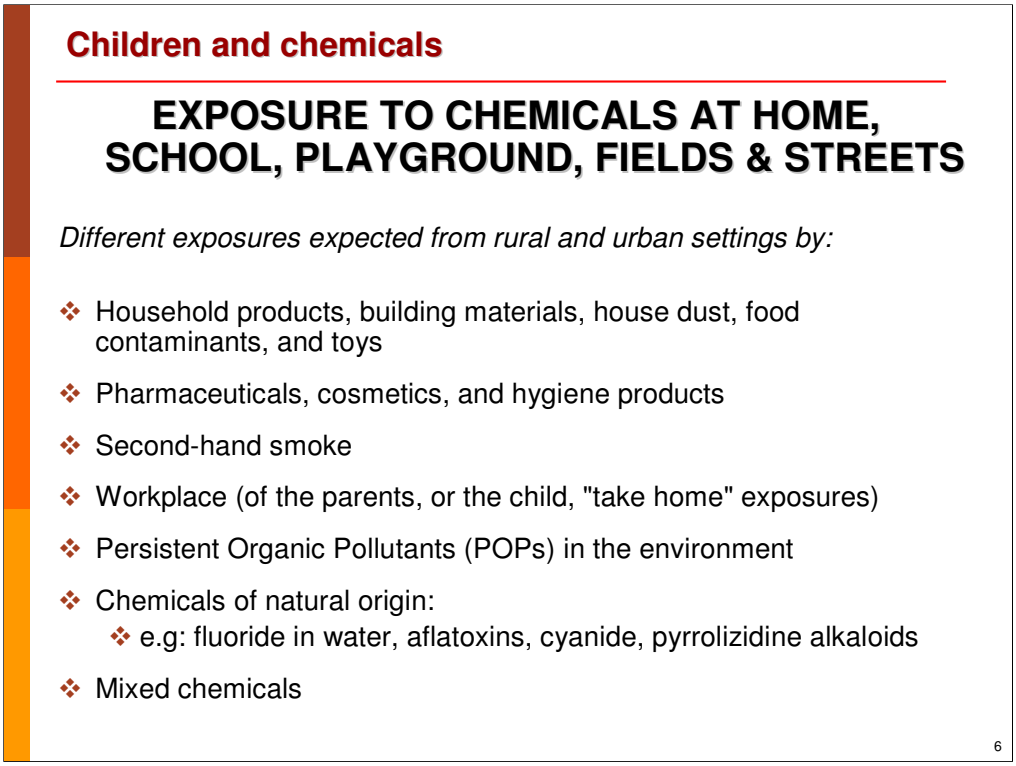
<<READ SLIDE>>

Ref:

•WHO. Children's health and the environment: a global perspective. Pronczuk J, ed. *WHO*, Geneva, 2005

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Image: WHO



<<READ SLIDE>>

Children are exposed to myriad chemicals at home, at school, in the playground, in fields and streets, both in rural and urban environments.

<<NOTE TO USER: mention under each bullet, if appropriate, the examples that are relevant to the area.>>

Toxicants are present in or as:

• household products, building materials, house dust, and toys;

• unexpected contaminants in pharmaceuticals, or inappropriate cosmetics, and hygiene products;

• second hand smoke;

• chemicals in the workplace of the parents or the child; and also as "take home" exposures, e.g: when the working parent brings in contaminated clothes to the home: chemicals, solvents, metals, pesticides;

• persistent organic pollutants (POPs), and also other chemicals polluting the environment resulting of degradation products;

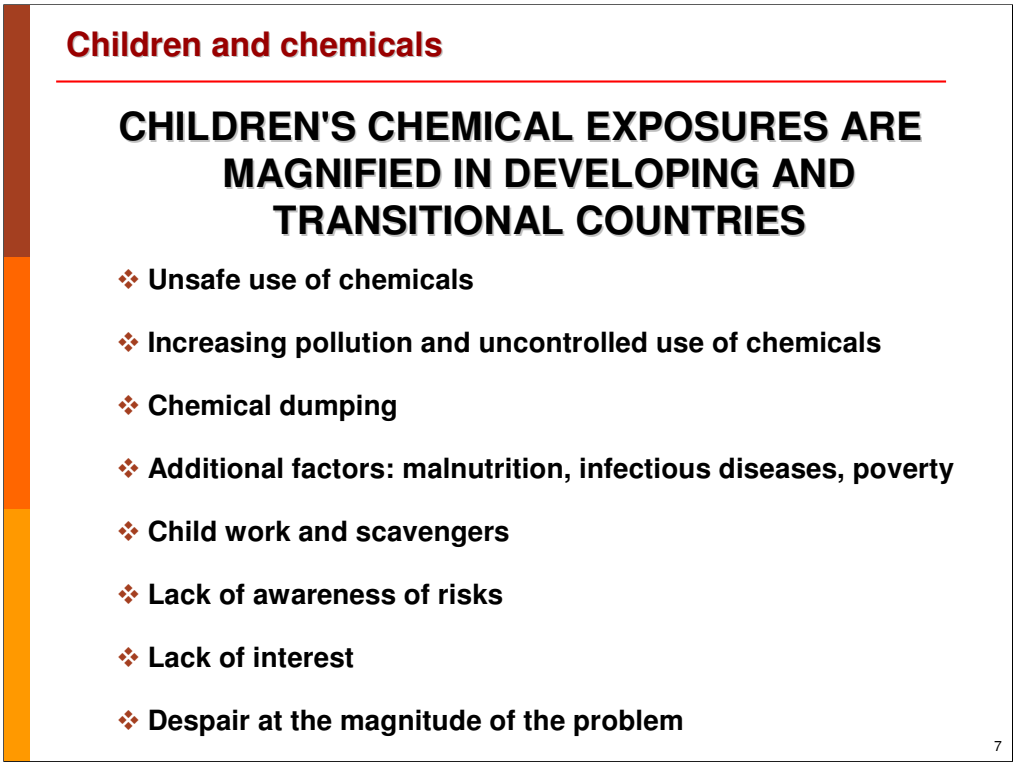
• chemicals of natural origin: including arsenic (As) and fluorides (Fl) in water, mycotoxins (e.g. aflatoxins), cyanogen radicals (plants that are rich in cyanide-generating compounds, e.g. Cassava – used as staple food in many African countries) and pyrrolizidine alkaloids (present in some plants that may be used to prepare herbal teas);

• mixed chemicals can result in additional and unexpected toxic effects, or synergic action on exposures.

Ref:

•WHO. Children's health and the environment: a global perspective. Pronczuk J, ed. *WHO*, Geneva, 2005

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011



Children's environmental health and chemical safety problems are magnified in developing countries and countries in transition and in the poor parts of the world for reasons including the following:

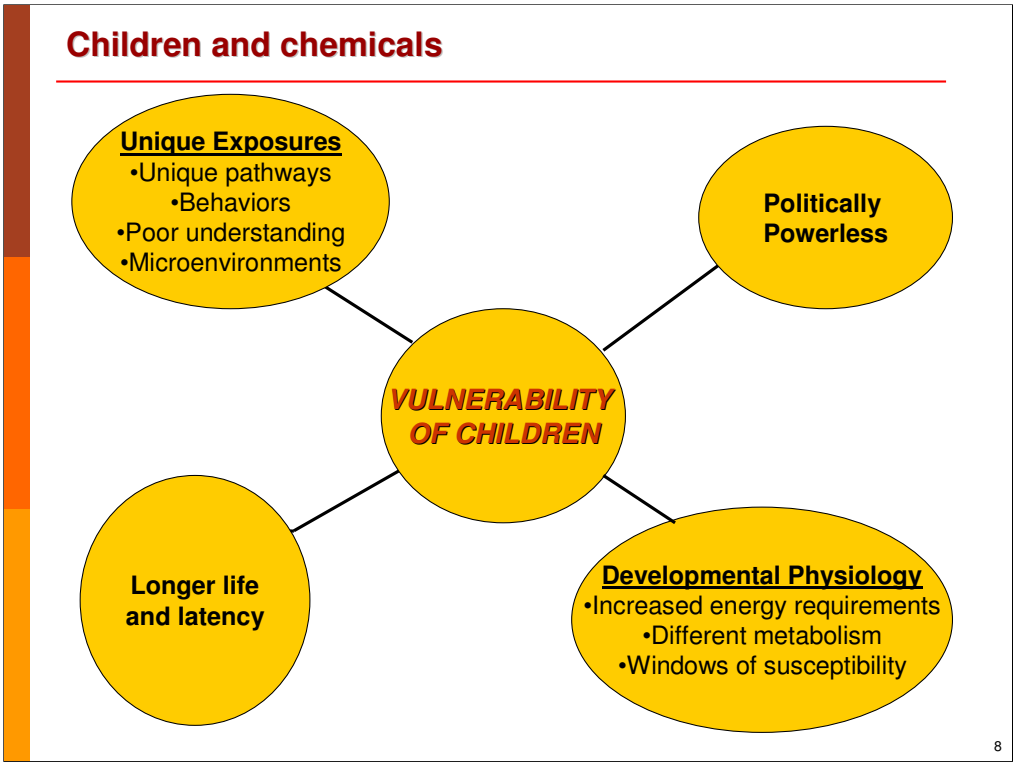
- unsafe use of chemicals – due to lack of information and education on their safe and judicious use and to prevailing illiteracy; illicit products;
- increasing pollution and uncontrolled use of chemicals – due to lack of appropriate regulatory measures or the impossibility of enforcing them (e.g. because of lack of personnel, controls and surveillance);
- chemical dumping and waste sites are adjacent to populated areas;
- additional factors such as malnutrition, infectious diseases and poverty;
- lack of awareness about risks, cultural aspects, and poor access to information;
- lack of interest because of other urgent, immediate health priorities;
- despair at the magnitude of the problem, which may seem impossible to solve.

<<NOTE TO USER: if appropriate, provide examples relevant to the area, to illustrate the points in the slide.>>

Refs:

•Goldman L, Tran N. Toxics and poverty: the impact of toxic substances on the poor in developing countries. *The World Bank,* Washington DC, 2002

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011



We now recognize that children, including the embryo, fetus, infant and all life stages until the completion of adolescence, are often at different and increased risk from environmental hazards than 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, they often receive higher exposures to pollutants found in air, water and food which may be handled quite differently by an immature set of systems from the ways 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 which can alter normal function and structure.

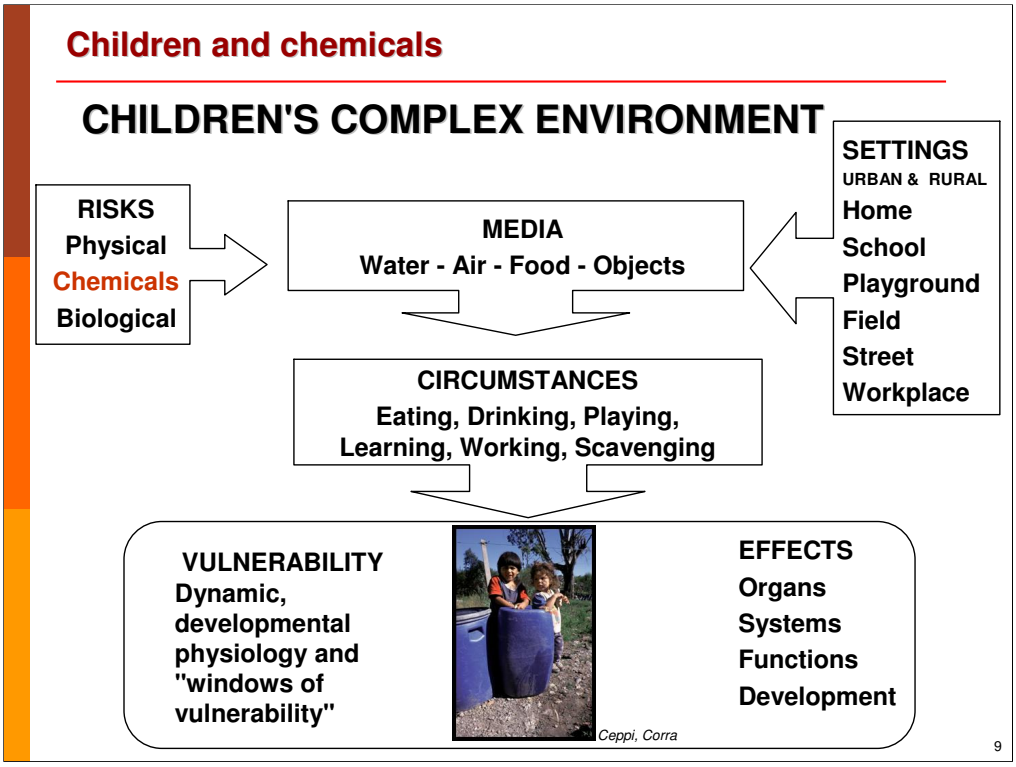
3. Children have a longer life expectancy. They have longer to manifest disease with a long latency period *(e.g. cancer)*, and longer to live with toxic damage.

4. Finally, children are politically powerless; they are defenseless. 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 series of slides.

Ref:

•Landrigan P, Garg A. Children are not little adults. In: *Children's health and the environment: a global perspective*. Pronczuk J, ed. WHO, Geneva, 2005:3-16.

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011



•This slide summarizes the way chemicals present in the environment (as a risk) may reach the child through media (e.g. water, air, food and objects) and during activities such as eating, drinking, playing, learning or working (and scavenging, in poor areas...).

•Chemicals are present in the places (settings) where children spend most time: including home, school, fields, playgrounds, streets – both in urban and rural areas.

•Children of different age groups are affected because of their special vulnerability – they are developing very rapidly, need high levels of nutrients and energy, have an "anabolic" metabolism and special “windows of vulnerability”.

•The effects of exposure to chemicals may have an impact on organs, which are developing, on systems and functions, which are maturing, and on the developmental process of growth.

Ref:

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Picture: Ceppi, Corra, Argentina. Used with permission.

TOXICOKINETICS AND TOXICODYNAMICS

- **Toxicokinetics -** all the processes and pathways that a substance goes through in the body
- **Toxicodynamics** the interaction between a substance and the body, resulting in toxic effects

Simply stated, toxicokinetics refers to what the body does to the toxin, while toxicodynamics refers to what the toxin does to the body

Children and chemicals

TOXICOKINETICS

How are xenobiotics handled by an immature, anabolic body?

- **Absorption**
  - Energy, water, oxygen consumption
- **Biotransformation**
  - Activation/detoxification
- **Distribution**
  - Fat
  - Blood-brain barrier
- **Elimination**
- **Critical windows of development**
  - Development of organs and systems

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•Toxicokinetics is the term given to all the processes and pathways that a substance goes through in the body (e.g. absorption, transportation, conversion or metabolism and elimination). Children have a dynamic physiology that is turned up to “high” because of growth demands. In addition, they are vulnerable to damage during the differentiation and maturation of organs and systems.

•Xenobiotics or “chemicals foreign to the biological system” utilize metabolic pathways intended for processing of nutrients and for eliminating metabolites. Some xenobiotics are dangerous as ingested and need to be detoxified by metabolism. Others are not dangerous when ingested but may become dangerous when metabolized (for example: paracetamol overdose, methyl alcohol). Children are in an "anabolic" state and require larger amounts of energy, water, oxygen and nutrients than do adults.

•Absorption is different and frequently increased in children because they are anabolic and active. They are geared to absorb nutrients very efficiently. eg: 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. Either way, these processes are likely to be different in children, but unfortunately not in predictable ways. Particularly during fetal growth and in the first 6–12 months of life, important metabolic pathways such as cytochrome P450 systems and glutathione conjugation are significantly reduced in efficiency. Most known toxicants are detoxified in the body, so immaturity of these systems increases the duration 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; therefore, substances such as lead readily cross into the central nervous system.

•Elimination may be decreased in early postnatal life. For example the glomerular filtration rate (GFR) of a newborn is less that 40% of that of an adult; 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.

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

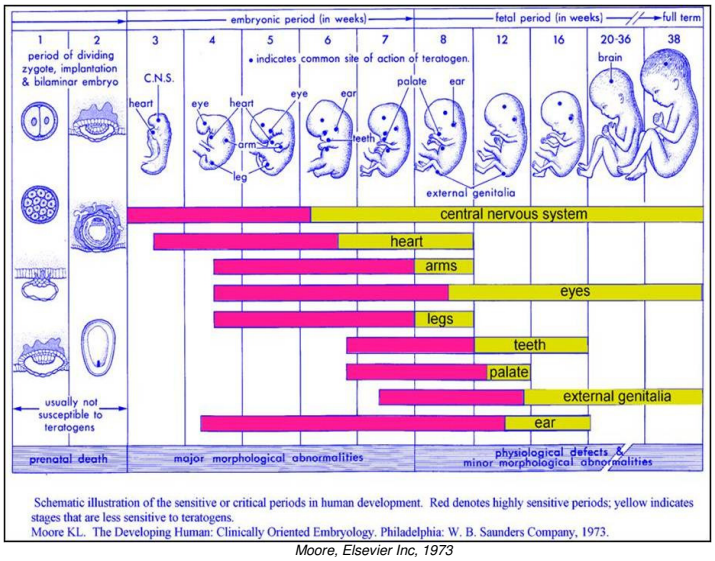
Ref:

•Ellenhorn MJ, Barceloux DG. Medical Toxicology: diagnosis and treatment of poisoning. *Elsevier*, New York, 1988.

Image: WHO

Children and chemicals

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

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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, diethylstilbestrol (DES)
- – ionizing radiation
- – methylmercury, lead

•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 maternal 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 both parents, as well as postnatal exposures can cause harm to children.

<<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. See the module on prenatal exposures for more information.>>.

Refs:

•Selevan SG et al. Windows of susceptibility to environmental exposures in children. In: *Children's health and the environment: a global perspective*. Pronczuk J. ed. WHO, Geneva. 2005: 17-26

•Stromland K et al. Autism in thalidomide embryopathy: a population study. *Developmental Medicine & Child Neurology*, 1994, 36(4):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.

Children and chemicals

TRANS-GENERATIONAL TOXICANTS

- Exposure occurs during youth
- Prolonged half lives (up to 10 years)

  As women enter childbearing years the toxicant moves transplacentally and has adverse effects on development

Examples:

- Polychlorinated biphenyls (PCBs) - Yusho and Yu-cheng
- Methyl mercury- Iraq

- Prevention is key

<< NOTE TO USER: for each type of chemical mentioned, describe examples of transgenerational exposure that are pertinent to the area and/or your personal experience on the subject.>>

Further, many persistent toxins, such as persistent organic pollutants (POPs), methylmercury enter the body at a young age and due to their long half lives (1-10 years) they persist long enough to have adverse fetal effects on the next generation. Exposures to these toxins that occur to a person at a very young age can have lasting effects into adulthood and into the next generation even when the mother has minimal to no symptoms.

Some examples include:

Polychlorinated biphenyls (PCB) exposure to Kanechlor occurred during making rice oil. This occurred in Japan in 1968 (called Yusho disease) and Taiwan 1979 (Yu-cheng disease). Children of Yusho and Yu-Cheng patients presented: reduced growth, dark pigmentation of the skin and mucous membranes, gingival hyperplasia, xerophthalmia, oedematous eyes, dentition at birth, abnormal calcification of the skull, rocker bottom heel. A high incidence of low birth weight was reported. Infants born to women who had been exposed to PCBs exhibited numerous effects, including neurobehavioural deficits and lower overall age-adjusted developmental scores among the exposed children.

Methylmercury exposure occurred in Iraq after contamination of crops. Effects on the fetus include spasticity, seizures, and neurodevelopmental delay.

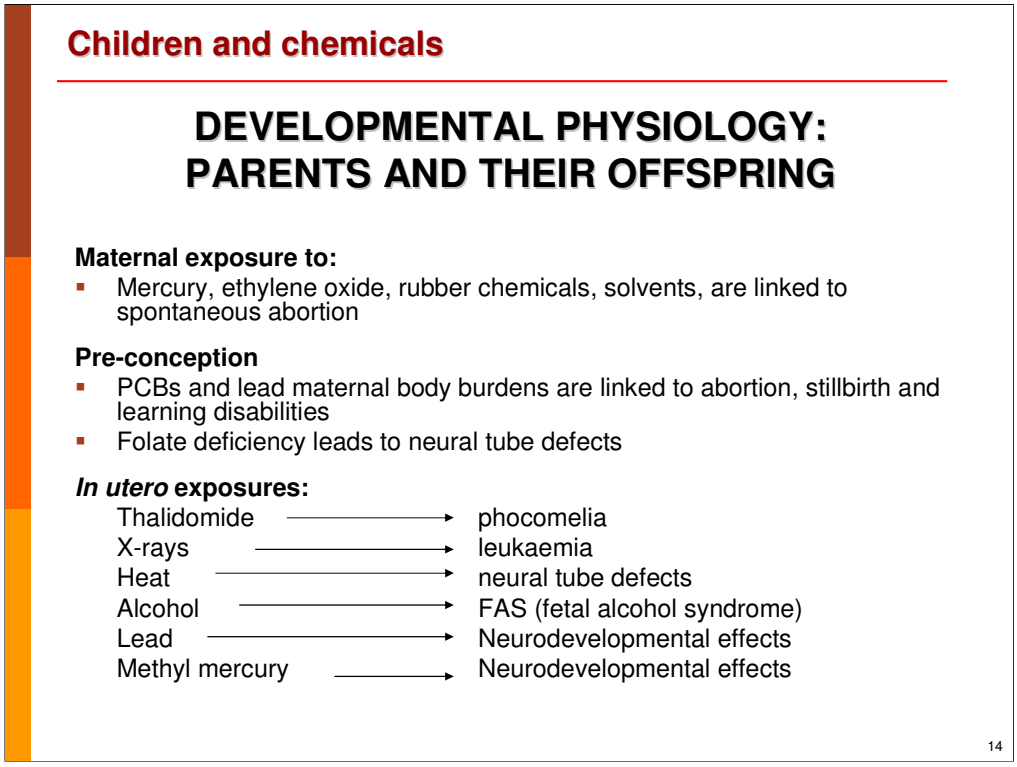
Therefore, preventing exposures to children, adolescent and females of child bearing age may reduce the toxicity that these chemicals have on their children

Refs:

•Rustan H, Hamdi T. Methyl mercury poisoning in Iraq a neurological study. *Brain*, 1974, 97 (1):499-510.

•Chen YC et al. A 6-year follow up of behavior and activity disorders in the Taiwan Yu-cheng children. *Am J Public Health,* 1994; 84:415-421.

•Kuratsune M et al, Analysis of deaths seen among patients with Yusho, (Abstract FL17), In: *Dioxin 86, Proceedings of the VI International Symposium on Chlorinated Dioxins and Related Compounds, Fukuoka, Japan*. 1986, p.179.



<<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. For more information, please see the reproductive health modules or module on developmental and environmental origins of disease.>>

Mother's 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. These are a few examples of chemicals and described effects observed in developmental of children since pre conception and *in utero* exposures.

Ref:

•Fine JS. Reproductive and perinatal principles. In: *Goldfrank's Toxicologic Emergencies, 8th ed*. The McGraw-Hill Companies, 2006.

PCBs: polychlorinated biphenyls

Children and chemicals

TOXICODYNAMICS
HOW DO TOXIC EFFECTS OCCUR?

- **During critical windows of exposure**
- **On critical organs/systems**
  - Central nervous system (CNS)
  - Immune system
  - Endocrine system
  - Other organs

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- ***A child is building the body for a "lifetime".***

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Toxicodynamics refers to the process of interaction between a substance and the organs or systems in the body, resulting in effects. It is equivalent to the "mechanism of action", "toxicity", or "toxic effects". Effects may occur during:

•*Critical windows of exposure*: every organ develops according to a strict "timetable" in which changes take place at specific times. There are periods during which an organ may be particularly sensitive to the adverse effect of a chemical, radiations or thermal conditions. These are called "critical windows of exposure". For example, in animal experiments, exposure to carcinogenic substances early in life is more likely to trigger cancer than a similar exposure during adulthood.

•*Central nervous system (CNS)*: this is a precisely regulated system that entails numerous processes. Cells divide, multiply, migrate and differentiate; cell connections are continually formed; numerous biochemical changes take place; neurotransmitters, synapses and receptors are set up to enable the effective transmission of signals. The "brain growth spurt" (period of rapid development) occurs in the fetus in the third trimester of pregnancy and continues into the first 2 years of life. The developing CNS is a potential target for neurotoxic substances.

•*Immune system*: the immune system develops from "pluripotent" stem cells that migrate from the circulatory system into lymphoid organs (liver, bone marrow, spleen, lymph glands) and differentiate into a wide variety of cell types (B- and T-lymphocytes, macrophages and granulocytes). The human immune system is fully formed but not totally protective at birth. Important developments occur after birth, in the interaction with the environment that leads to acquisition of immunological "memory". Toxicants, such as lead, and polychlorinated biphenyls (PCBs) may alter the pluripotent stem cells, the T-lymphocytes, the thymus.

•*Hormone-dependent sexual development*: hormones are "signalling" substances that enable molecules, cells, tissues and organs to function in a harmonized manner and interact with the environment. Hormones play a crucial role in gender differentiation. Although gender is determined genetically after fertilization, the gonads remain unchanged until week 6, when male sex hormones cause the embryo to develop as a male. Later on, hormones control puberty, ovule maturation, spermatogenesis, gestation, birth and lactation.

•The thyroid produces hormones which are crucial for the correct development of organs, such as the brain and the gonads. Some chemicals have been proved to have an endocrine-disrupting (ED) capacity in wildlife, and the *possibility* of such effects in humans is taken seriously as these effects are biologically plausible. The effects may occur by "mimicry" (behaving like hormones), antagonism (preventing their bonding) or disrupting production, conversion, transportation or excretion of hormones.

<<NOTE TO USER: For supplemental guidance for assessing cancer susceptibility from early-life exposure to carcinogens, please see USEPA materials (2005) at www.epa.gov/raf/publications/pdfs/CHILDRENS_SUPPLEMENT_FINAL_.PDF – accessed March 2011.>>

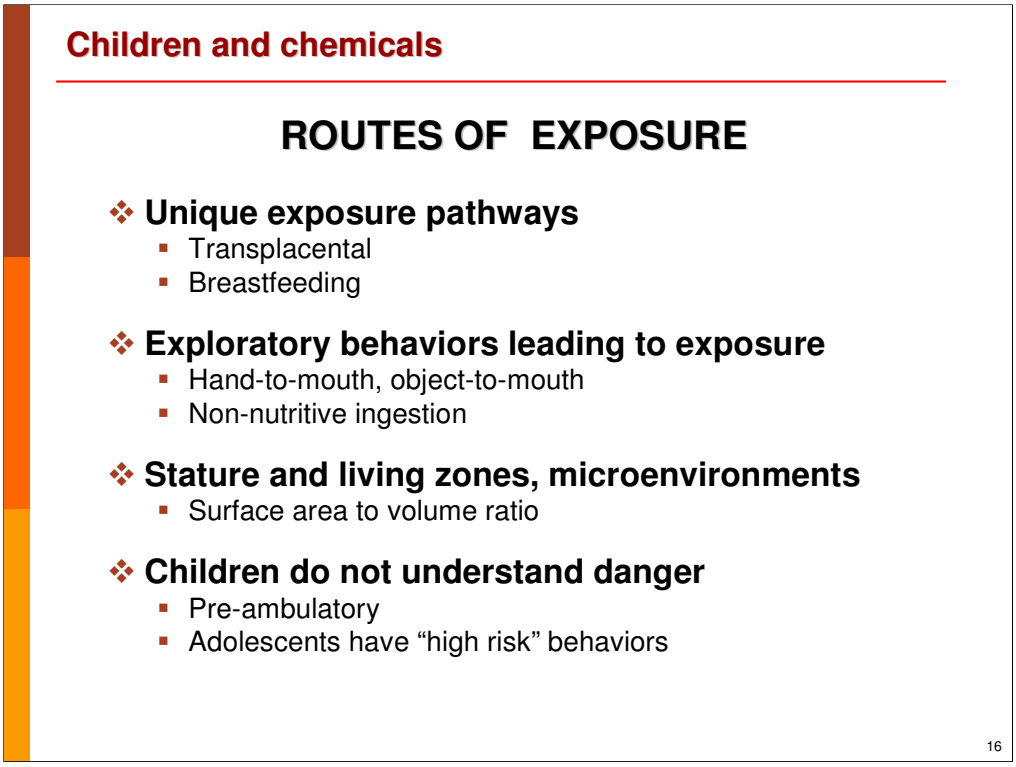
Refs:

•Dewailly E et al. Susceptibility to infections and immune status in Inuit infants exposed to organochlorines. *Environmental Health Perspectives*, 2000, 108(3):205-211.

•Fine JS. Reproductive and perinatal principles. In: *Goldfrank's Toxicologic Emergencies, 8th ed*. The McGraw-Hill Companies, 2006.

•Health Council of the Netherlands. Pesticides in food: assessing the risk to children. *The Hague, Health Council of the Netherlands Report*, June 7, 2004. Available at *www.gezondheidsraad.nl/sites/default/files/Pesticides%20in%20food.pdf* – accessed March 2011.

Image: WHO



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

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

•Their physical differences also cause them to reside in a different location in the world; they are closer to the ground so heavy pollutants such as mercury will concentrate in their breathing zone and deliberate applications of pesticides and cleaning solutions makes them more readily accessible to small children. Because they are small, they have a high surface area to volume ratio and can have dramatically increased absorption through dermal contact when compared with that of adults.

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

Ref:

•Landrigan P, Garg A. Children are not little adults. In: *Children's health and the environment: a global perspective*. Pronczuk J, ed. WHO, Geneva, 2005:3-16.

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Children and chemicals

MEDIA OF EXPOSURE

- **Water**
  - Drinking
  - Recreational
- **Air**
  - Indoor
  - Outdoor
- **Food**
- **Cosmetic and hygiene products**
- **Objects and toys**

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<< NOTE TO USER: for each medium of exposure, mention the examples that are pertinent to the area and/or your personal experience on the subject.>>

•*Water*: Used for drinking, cooking, preparation of infant formula, bathing and swimming. Groundwater or surface water may be contaminated by "point" sources of pollution (e.g. industrial discharge) or "non-point" sources such as agricultural and rural run-off, soil contamination and atmospheric deposition. Some contaminants of concern are: arsenic, chromium, lead, mercury, nitrates, benzenes, pesticides, polychlorinated biphenyls (PCBs) and disinfectants (such as chloramine and chlorine).

The upper photo illustrates a situation commonly seen in poor areas, where children play and spend time in contact with unsafe water.

•*Air*: It is important to differentiate between indoor and outdoor pollutants. Indoor pollutants include particulate matter, gases, vapours, (also biological material and fibres). These contaminants are produced by tobacco smoke, stoves and construction materials. Pesticides and other chemicals for household use are present in the home. Outdoor pollutants vary according to density of traffic, extent of industrialization, time (of the year and of the day) and climate. The six main outdoor pollutants are: ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$), lead, sulfur dioxide (SO_2), carbon monoxide (CO) and nitrogen oxide (NO_2).

•*Food*: Food may have a large range of contaminants: from additives (colourings, flavourings and preservatives) to pesticides (as residues or as contaminants) and mycotoxins, and other natural toxins in doses high enough to produce toxic effects (some shellfish and fish toxins). Mercury and PCBs can contaminate fish and mycotoxins can contaminate grains. Special attention should be paid to the diet of infants, children and adolescents in order to assess potential exposure to toxicants.

•*Cosmetic and hygiene products*: a number of products applied to children may contain chemicals with toxic effects (e.g. talcum powder and body lotions.)

The photo illustrates a little girl with "surma" or kohl applied to her eyes – in some instances "surma" may be contaminated with lead.

•*Objects*: toys, baby cots and other materials that come into close contact with children may have toxic components or contaminants, such as leaded paint used on wooden toys. In the medical domain, there is concern about the presence of phthalates in tubes and in catheters, as well as in pacifiers. These products may also be found in toys.

Refs:

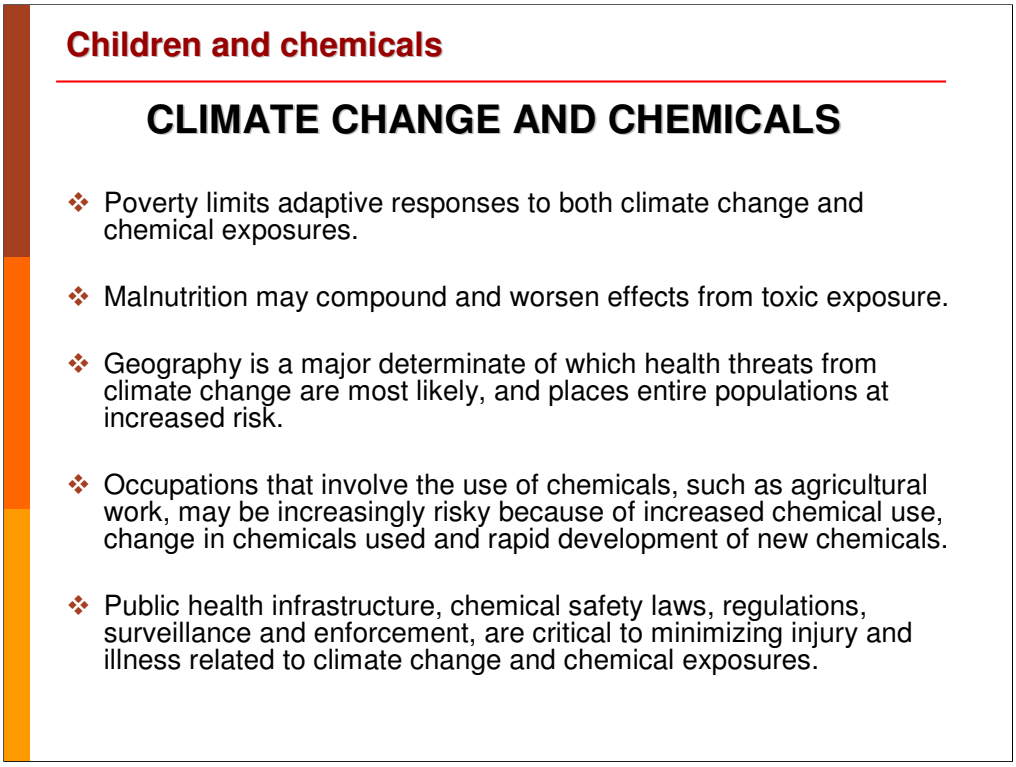
•American Academy of Pediatrics Committee on Environmental Health. Chemical and physical hazards. In: Etzel RA, Balk SJ, eds. *Pediatric Environmental Health, 2nd edition.* Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Image:

Top: Pan American Health Organization

Bottom: WHO



Just as climate change will affect different parts of the globe differently, climate change-related chemical exposures may pose disproportionate threats to populations in high risk groups.

•Poverty limits adaptive responses to both climate change and chemical exposures.

•Malnutrition, particularly in the very young, may compound and worsen effects from any toxic chemical exposure.

•Geography is a major determinate of which health threats from climate change are most likely, and places entire populations at increased risk. For example, low lying coastal communities are more susceptible to floods and storms which may be complicated by chemical contamination of drinking water, fields, food crops, and living spaces.

•Occupations that involve the use of chemicals, such as agricultural work, may be increasingly risky because of increased chemical use, change in chemicals used and rapid development of new chemicals.

•Public health infrastructure, including the health care systems, as well as chemical safety laws, regulations, surveillance and enforcement, are critical to minimizing injury and illness related to climate change and chemical exposures. In those areas where these basic services are lacking, whole populations are at increased risk.

Ref:

•Shea K et al. Managing chemicals in a changing climate to protect health. *IFCS*, 2008. Available at www.who.int/ifcs/documents/general/clim_change.pdf – accessed May 2011.

Children and chemicals

TOXIC SUBSTANCES IN TOYS AND ARTICLES

U.S. Environmental Protection Agency

- **Toys:** lead, cadmium and phthalates
- **Jewellery:** lead, cadmium
- **Electronic products:** lead, mercury, cadmium, and brominated flame retardants
- **Batteries:** lead and other heavy metals
- **Textiles :** perfluorinated compounds in waterproof garments, nonylphenol ethoxylates as surfactants
- **Furniture :** fungicides

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There is a growing interest and understanding of the potential exposure to chemicals contained in commonly used articles. Chemical substances provide important functionality in a wide range of products. Many chemicals can be used with a high degree of safety when best practices are followed. However, the use of toxic chemicals in articles is a growing concern for public health and the environment. Solving the problems posed by toxic substances in articles will require action on many levels, from research and development to information systems or regulations. At present, there is no global system for management of information about substances in articles.

•***Toys:*** increased use of toys, the prevalence of imported toys with unknown material composition, use of toxic metals in toys, lack of information on hazards of toys, ineffective regulation on toy safety, the possibility of recalled toys being sent to developing countries where there is little control, and likelihood of recycled plastics with often unknown content of hazardous substances. Toys and children's jewellery can contain lead in the form of lead paint and metal clasps, chains or charms. Lead is also used in crayons, as a stabilizer in some toys. Lead may leach out of these products when they are used by children and when discarded.

•***Electronic products:*** many toxic materials are found in personal computers, including lead, cadmium, mercury, beryllium, antimony, brominated flame retardants, perfluorinated compounds, and polyvinyl chloride plastic. Developing countries and countries with economies in transition bear a particularly large burden from unsafe disposal and recycling of these articles.

•***Batteries:*** may include lead and other heavy metals, improper recycling of batteries can contaminate environment resulting in chronic exposure and poisonings in surrounding areas.

•***Textiles:*** perfluorinated compounds *(*PFCs) are commonly used as stain- and water-repellents in textile surfaces and are applied during the production of all-weather clothing and other textiles such as tents and tablecloths. Unbound PFC chemicals on treated textiles are released during wear, washing and disposal.

•***Furniture:*** the use of fungicides in furniture can cause skin irritation and allergenic effects.

Refs:

•Massey RI et al. Toxic substances in articles: the need for information. *TemaNord*. Nordic Council of Ministers, Copenhagen, 2008:596. Available at *www.norden.org/en/publications/publications/2008-596* – accessed March 2011

•U.S. Environmental Protection Agency. Lead and cadmium in toy jewellery. *USEPA*, Washington DC, 2004. Available at *www.epa.gov/lead/pubs/toyjewelry.htm* – accessed March 2011.

•WHO. Childhood lead poisoning. *WHO*, 2010. Available at *www.who.int/ceh/publications/childhoodpoisoning/en/index.html* - accessed March 2011.

•WHO. Children's exposure to mercury compounds. *WHO*, 2010. Available at *www.who.int/ceh/publications/children_exposure/en/* - accessed March 2011.

•WHO. Lead exposure in children. Information note. *WHO*, August 2007. Available at *www.who.int/phe/news/Lead_in_Toys_note_060807.pdf* – accessed March 2011

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Image: United States Environmental Protection Agency. Lead in Toy Jewelery. Washington, DC, USA, United States Environmental Protection Agency, 2004. Available at www.cpsc.gov/cpscpub/prerel/prhtml04/04174.html - accessed March 2011.

Children and chemicals

SOURCES OF EXPOSURE IN THE ENVIRONMENT

- **Anthropogenic "man-made"**
  - Industry
  - Traffic
  - Additives and contaminants
  - Contaminated areas
- **Natural**
  - Arsenic
  - Fluoride
  - Plants
  - Aflatoxins
  - Blue-green algae

WHO

Ceppi, Corra

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<< NOTE TO USER: for each source of exposure mention examples that are pertinent to the area and/or your personal experience on the subject.>>

•Anthropogenic sources are those of human origin ("man-made") or industrial. These include the pollution of the environment due to traffic and pesticide residues in food. As illustrated very graphically in the drawing at the top of the slide made by a schoolchild in India, in preparation for World Health Day 2002, clouds of air pollutants appear with a "devilish" face.

•Some chemicals are naturally present in the environment, but they can also cause adverse effects in humans. Natural chemicals can also be augmented by human activity like mercury and mining, nitrogen and fertilizer. Typical examples are the elements:

– arsenic in water causing arsenicosis;

– fluoride in water causing fluorosis and fluoride in the air (produced from the burning of fluoride-rich coal);

Other chemicals of natural origin include:

– blue-green algae toxins in recreational waters;

– aflatoxins in food (these mycotoxins may contaminate maize and other stored grains). They have toxic effects on the liver, immune system and other organs, affecting especially children. They represent a public health problem in many African and Asian countries;

– cyanogenic (or cardiac) glycosides in some foodstuff (e.g. cassava, foxglove, oleandar);

- envenomations due to bites and stings.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Chemical and physical hazards. In: Etzel RA, Balk SJ, eds. *Pediatric Environmental Health, 2nd edition.* Elk Grove Village, IL: American Academy of Pediatrics, 2003.

Image

Top: WHO.

Bottom: Ceppi, Corra, Argentina. Used with permission.

Children and chemicals

CIRCUMSTANCES OF EXPOSURE

- Unintentional ("accidental")
- Intentional
- Iatrogenic
- Occupational
- 'Take-home'
- *ENVIRONMENTAL*

WHO

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<< NOTE TO USER: for each circumstance of exposure mention the examples that are pertinent to the area and/or your personal experience>>

The potential circumstances of exposure to chemicals in children are listed here:

•**Unintentional** – also called "accidental" (although this term should be avoided to reduce the implication of "inevitability") – is the most common circumstance of exposure in small children who are "little explorers", ready to touch and taste everything at their "ground-level" microenvironment (e.g. colourful pills, berries and plastic bottles).

•**Iatrogenic** – observed mainly in the medical setting, when medications are wrongly administered (e.g. overdose or medication error).

•**Intentional** – although infrequent in children, this may occur in socially poor environments, when children are in the care of psychologically unstable people or living under social unrest. These intentional exposures include:

– Homicide – e.g. children overdosed with pharmaceuticals, intentionally exposed to carbon monoxide or administered toxicants;

– Munchausen syndrome – simulation or induction of disease in children, in this case through the administration of pharmaceuticals or chemicals, usually by psychologically disturbed individuals close to the child;

– "Chemical" battering – a form of child abuse, through the administration of pharmaceuticals and other substances (e.g. sedatives, sleeping pills, table salt or others);

– Solvent abuse ("sniffing") – a form of recreational drug use and abuse, seen in older children and adolescents;

– Suicide attempt or "gesture" – real or attempted suicides, observed mainly in psychologically unstable adolescents;

– Abortifacient – use of abortion-inducing substances by female adolescents frightened by the consequences of unwanted pregnancy; and

– Warfare agents – exposure of children to chemicals used in the context of war.

•**Occupational** – young workers being exposed to dangerous and/or unsafe chemicals in the workplace when engaged in child labour, or "take-home exposure" by parents. Pregnant women can also expose their unborn child at work. Furthermore, working parents may bring chemicals back to the home on their clothes, skin, or hair via "take-home exposures" if they are not adequately protected from chemical exposures while at work.

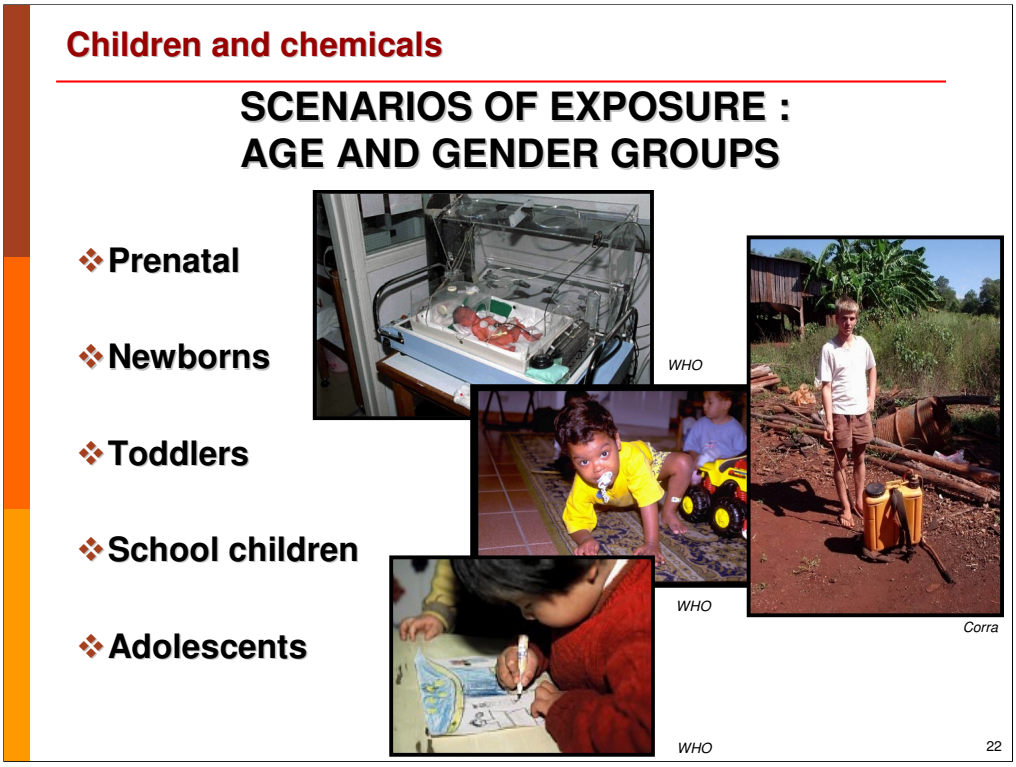
•**Environmental** – a growing cause of concern and relatively "new" approach to children's health, which has gained recognition in recent decades. It refers to the exposure of children to chemicals present as pollutants or contaminants in their environment. These chemicals may be from anthropogenic or natural sources.

Refs:

•Makalinao I, Woolf A.D. Poisonings and envenomings. In: *Children's health and the environment: a global perspective*. Pronczuk J. ed. WHO, Geneva, 2005: 153-176.

•Tennassee M. Where the child works. In: *Children's health and the environment: a global perspective*. Pronczuk J. ed. WHO, Geneva. 2005: 46-53.

Image: WHO



<< NOTE TO USER: for each scenario, mention the examples that are pertinent to the area and/or your personal experience on the subject.>>

The most common "scenarios" of acute and/or chronic exposure to chemicals for the different age-groups:

•*Prenatal-* parental exposure to chemicals prior to conception. Children can also be exposed *in utero* to toxic environmental agents that cross the placenta.

•*Newborns* – exposure of newborns to chemicals is infrequent, but may occur in a medical setting. This can occur due to medical error or drug contaminants or when newborns are administered inappropriate chemicals. As an example, in the nineties, the Swiss daily newspaper *Le Matin*, published details of two lethal cases of poisoning that had occurred in a Belgian hospital as a result of mistaken use of potassium chloride. Two pre-term babies died because they had received potassium chloride that came from wrongly labelled flasks that were supposed to contain a glucose solution. (*Dr. J. Pronczuk, personal communication*).

<< NOTE TO USER: Concern about breast milk contaminants may be addressed at this point, if relevant. Please make sure that the right message is received by the audience and "breast milk is the best food for infants". The importance of breast-feeding must be emphasized. See slides in "Children are not little adults". >>

•*Toddlers* – as they start moving around, exploring, touching and testing, toddlers may come into contact with or ingest cleaners, pesticides and other products unsafely stored in the home and these may be toxic or caustic. One of the main dangers to toddlers is the ingestion of caustic products that may cause permanent damage to the mouth and oesophagus. *Schoolchildren* – artwork may expose children to pigments and solvents, and unsafe science laboratory work may expose students to toxic compounds and fumes. School buses may also be a source of exposure to chemicals, as in the case of faulty combustion and carbon monoxide release.

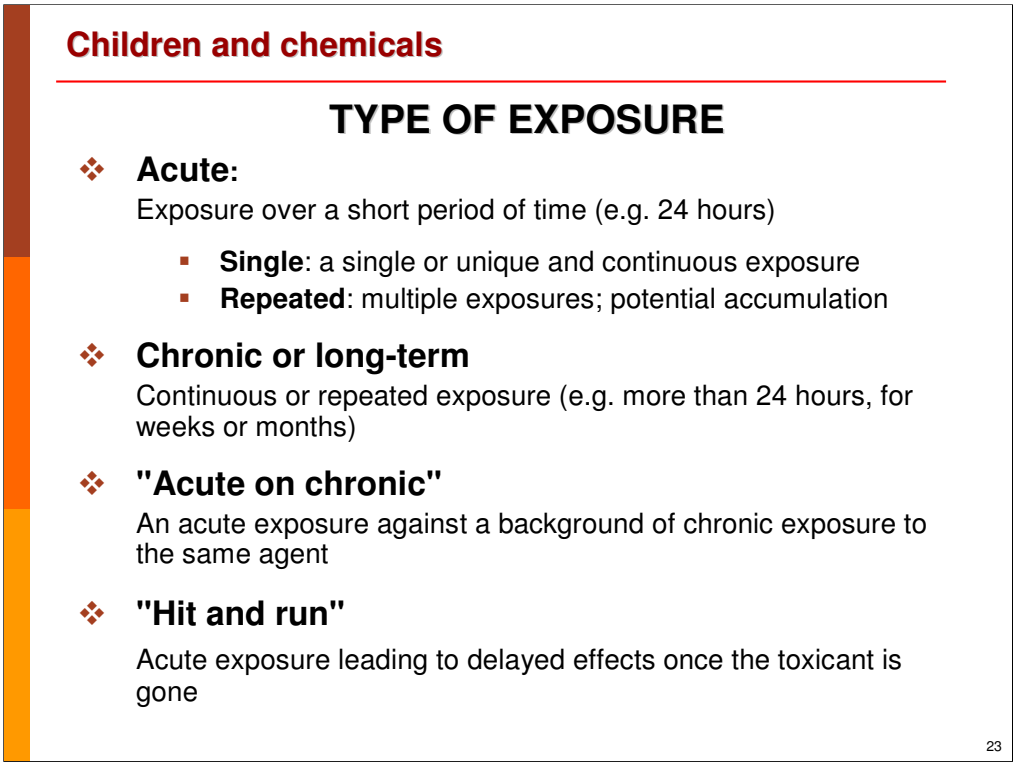
<< NOTE TO USER: Consider mentioning the case reported by Dr. Shannon (Boston) regarding schoolchildren exposed to the fumes of school buses whose engines were kept running under the window of a classroom. All children suffered intense headaches and malaise of unknown origin until carbon monoxide was found to be the cause. See Paediatric Environmental History module. >>

•*Adolescents* – Young workers who are poorly trained in safe working practices may be exposed to cleaners, pesticides or other chemicals at work. This is also the age when experimentation with drugs may start and youngsters may sniff or inhale solvents, many of which have marked effects on the central nervous system.

Ref:

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Images: WHO except image on the right: L. Corra. Adolescent working with pesticides, Argentina. Used with permission.



<< NOTE TO USER: for each type of exposure, mention the examples that are pertinent to the area and/or your personal experience on the subject.>>

Each type of exposure has unique effects on the physiologic system of the developing child.

Acute poisonings

Acute poisonings result from exposure to an agent over a short period of time e.g. 24 hours. Acute poisonings may be:

- *Single*: a single or continuous exposure to an agent over a short period of time e.g. for 24 hours (e.g. carbon monoxide).
- *Repeated*: multiple exposures to an agent over a short period of time e.g. 24 hours, where there may be accumulation (e.g. aspirin overdose).

Chronic exposures

Chronic exposures are continuous or repeated exposures e.g. for more than 24 hours, for weeks or months, as is the case of lead poisoning. Other examples include long term effects of arsenic exposure causing skin or bladder cancer.

"Acute on chronic"

"Acute on chronic" is an acute exposure against a background of chronic exposure to the same agent (e.g. organophosphorus pesticide exposure on a chronically exposed child).

"Hit and run"

Acute exposure leading to delayed effects once the toxicant is gone (e.g. thalidomide exposure during gestation leading to phocomelia, diethylstillbesterol exposure *in utero* leading to cervical cancer).

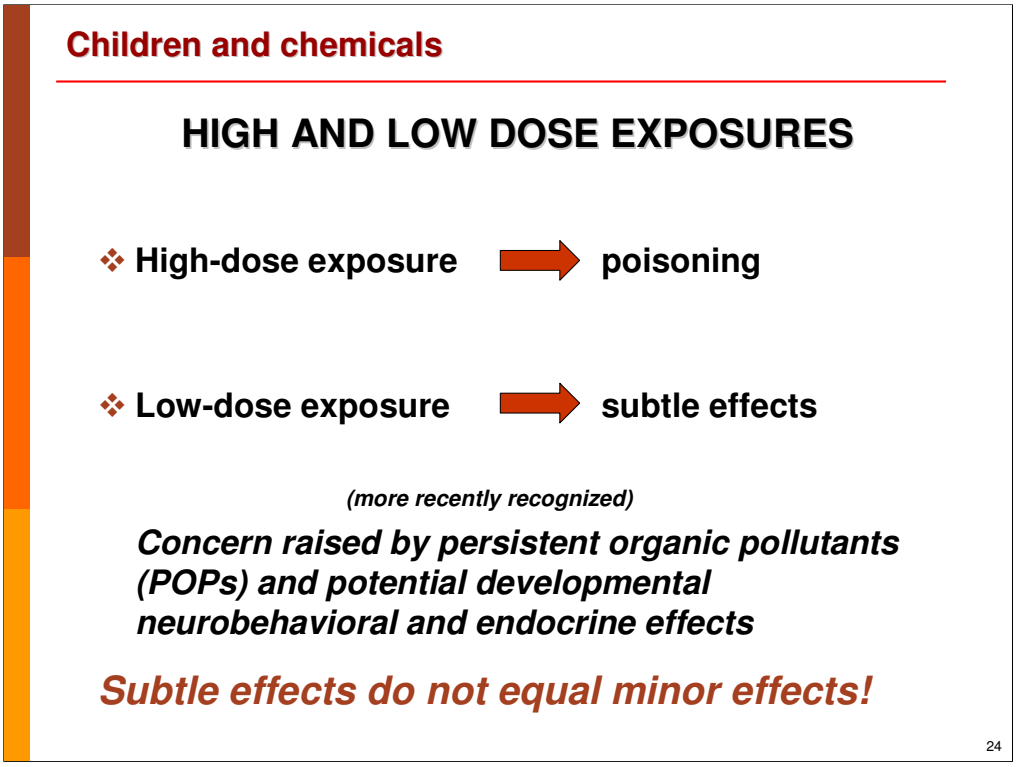
Effects shown – or not – depend upon the type of exposure, dose and opportunity (timing) as well as on the characteristics of the chemical involved and the clinical, nutritional and developmental status of the child. While acute poisonings are often the easiest to identify or diagnose, the other exposure types can be equally or more severe, but difficult to diagnose. Therefore, they pose a special challenge for the health care provider.

Refs:

•WHO. Harmonized data collection. In: *International Program on Chemical Safety, authority lists and definitions for the INTOX data management system.* WHO, 2000. Available at *www.who.int/ipcs/poisons/harmonization/en/* - accessed March 2011

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

•WHO/UNICEF. World report on child injury prevention. WHO, Geneva, Switzerland, 2008.



Effects depend on the type of chemical, the dose and timing of exposure (examples will be presented in future slides).

In general:

•High-dose exposures tend to produce poisoning and the diagnosis is usually quite clear, e.g.: the child is found with an empty bottle of medicine and presents drowsiness.

•Low-dose exposures may produce undetected or subtle effects, which may be difficult to diagnose, e.g.: lead exposure and anaemia.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Chemical and physical hazards. In: Etzel RA, Balk SJ, eds. *Pediatric Environmental Health, 2nd edition.* Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•WHO. Children's health and the environment: a global perspective. Pronczuk J. ed. *WHO*, Geneva, 2005.

Children and chemicals

CLINICAL AND SUBCLINICAL EFFECTS

Clinical features observed depend upon:

- Agent (chemical, physical, biological)
- Dose
- Timing and length of exposure

May be:

- Asymptomatic
- Acute and evident: toxic syndromes
- Chronic and subtle: undefined symptoms
- Detected only by laboratory studies

WHO

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<< NOTE TO USER: mention clinical examples that are pertinent to the area and/or your personal experience on the subject.>>

The clinical effects observed in children depend upon the type of chemical or pollutant involved, the dose, timing and length of exposure. Typical examples include:

•Some exposures may not produce obvious clinical effects, but will lead to disease after some time or in adulthood (e.g. air pollutants, arsenic in water).

•Acute poisoning by organophosphorus pesticides, with a characteristic "syndrome“: miosis, sweating, headache, brachychardia, convulsions.

•Chronic lead exposure: the child may be asymptomatic for some time and later present anaemia, abdominal pain, fatigue, behavioural changes and learning disabilities.

•In some instances, these exposures may be assessed through laboratory studies in individuals. Some effects may only be apparent through evaluation of large populations (i.e. IQ testing and population level exposure to PCBs or lead).

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health, 2nd edition. Etzel RA, Balk SJ, eds. Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

Image: WHO

Children and chemicals

ACUTE POISONINGS

According to Poisons Centres :

- **Up to 50% to 70% of the calls are about children exposed to chemicals or actually poisoned**
- **Number of poisoning cases is underestimated**
- **Cases of exposure are mostly acute and accidental**
- **The majority are between 1 & 4 years old**
- **Boys are more affected**
- **The outcome is usually favourable**
- **Mortality is usually low**

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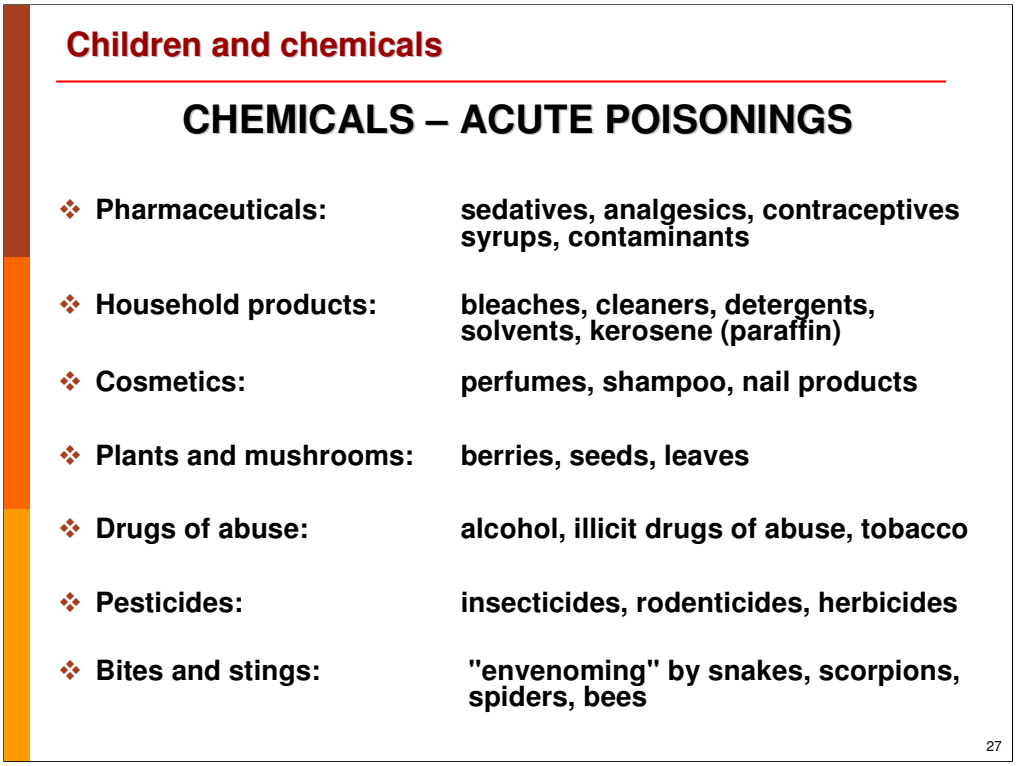
<<READ SLIDE>>

<< NOTE TO USER: Insert data and statistics provided by the local poisons control centre.>>

Ref:

•WHO. World directory of poison centres. WHO, Geneva, Switzerland, 2008. Available at *www.who.int/ipcs/poisons/centre/directory/en/* - accessed March 2011

Image: United States Environmental Protection Agency. Used with permission. Copyright notice: works produced by the U.S. Government are in the public domain.



<<READ SLIDE>>

<< NOTE TO USER: For each type of chemical mentioned, give examples of acute poisons pertinent to the area and/or your personal experience on the subject.>>

This list includes the types of chemicals most commonly involved in acute childhood poisonings – those that are the most accessible to children in the home and its surroundings. Please include regional information provided by poison control centres.

Note that:

•Pharmaceuticals may also include potentially dangerous medicines which are not classically considered medications such as, dietary supplements, traditional/cultural remedies and over the counter medicines.

•Household products may also include mercury filled thermometers, dyes, batteries

•Some cosmetics may contain heavy metals

•Plants – even some decorative plants such as the poinsettia or other yard plants (such as foxglove, oleander) may be hazardous to a child's health.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Chemical and physical hazards. In: Etzel RA, Balk SJ, eds. *Pediatric Environmental Health, 2nd edition.* Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•Fine JS. Reproductive and perinatal principles. In: *Goldfrank's Toxicologic Emergencies, 8th ed*. The McGraw-Hill Companies, 2006.

•Makalinao I, Woolf A.D. Poisonings and envenomings. In: *Children's health and the environment: a global perspective*. Pronczuk J. ed. WHO, Geneva, 2005: 153-176.

•WHO. World directory of poison centres. WHO, Geneva, Switzerland, 2008. Available at *www.who.int/ipcs/poisons/centre/directory/en/* - accessed March 2011

•WHO/UNICEF. World report on child injury prevention. WHO, Geneva, Switzerland, 2008.

Children and chemicals

ACUTE POISONINGS

Pharmaceuticals: one teaspoon or pill can be dangerous!

- Benzodiazepines
- Tricyclic antidepressants
- Codeine
- Diphenoxylate (Lomotil)
- Theophylline
- Antidiabetic sulfonylureas
- Digitalis
- Antihypertensives
- Methyl salicylate
- Iron
- Quinidine
- Chloroquine
- Lindane
- Camphor

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<< NOTE TO USER: for each type of chemical mentioned, give examples of acute poisons, pertinent to the area and/or your personal experience on the subject.>>

Focusing on pharmaceuticals for a moment: while these may often be therapeutic to adults, if ingested by a child many pharmaceuticals have the potential to be fatal at very small doses.

This is a list of some medications that can be dangerous and fatal to a child with even one pill or teaspoon, and most clinicians should be familiar with.

<<READ SLIDE>>

Refs:

•Koren G. Medications which can kill a toddler with one teaspoon or tablet. *Clinical Toxicology*, 1993, 31(3):407-413.

•Olson KR (ed). Poisoning & Drug Overdose, 5th ed. *Lange Medical Books*. McGraw-Hill, New York, 2007.

Image: WHO

Children and chemicals

PESTICIDES

- Spraying of pesticides at home and in schools increases exposure to children due to:
  - Higher concentrations near the floor
  - Persistence in some surfaces, such as carpets and soft toys
  - Overuse and misuse of pesticides
- Children activities contribute to inhalation of pesticides
  - Crawling
  - Playing close to the floor
  - Hand-to-mouth and object-to-mouth activities

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<<READ SLIDE>>

Spraying pesticides at home results in increased risks to children because of higher concentrations near the floor and persistence of insecticides in carpets, porous surfaces, toys etc. Activities of young children (exploratory, hand to mouth activities, crawling on the floor with exposed skin) also contribute to higher exposure.

<<NOTE TO USER: For more information regarding pesticides, please refer to the Pesticide module.>>

Ref:

•Reigart JR, Roberts JR. Pesticides in Children. *Pediatric Clinics of North America*, 2001, 48(5):1185.

Children are exposed to a wide range of pesticides, including insecticides, herbicides, fungicides, and rodenticides. They differ from adults in their exposures and responses to exposures. Acute and chronic toxicity are discussed, and important chronic effects such as carcinogenesis, endocrine disruption, and neurodevelopment effects are reviewed. The state of laws and regulations are also discussed. Recommendations are made to pediatricians regarding treatment and advising families regarding avoidance of pesticide exposures and their effects.

Image: WHO

Children and chemicals

SOLVENTS & VOLATILE ORGANIC COMPOUNDS

Aromatic hydrocarbons, alcohols, aldehydes, ketones.

Sources:

- Solvents, fabric softeners, deodorizers and cleaning products
- Paints, glues, resins, waxes and polishing materials
- Spray propellants, dry cleaning fluids
- Pens and markers
- Binders and plasticizers
- Cosmetics: hairspray, perfumes

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<<READ SLIDE>>

<<NOTE TO USER: For more information concerning this topic, please refer to the Indoor air pollution module.>>

Organic chemicals are widely used as ingredients in household products: paints, varnishes, wax, cosmetic, degreasing, wood preservatives, aerosol sprays, cleansers, disinfectants, moth repellents, air fresheners, aerosol insecticides, mosquito coils, and hobby products. Fuels are also made up of organic chemicals.

These products can release organic compounds while you are using them, and, to some degree, when they are stored.

Levels of several volatile organics average 2 to 5 times higher indoors than outdoors. During and for several hours immediately after certain activities, such as paint stripping, levels may be 1,000 times higher than outdoor levels.

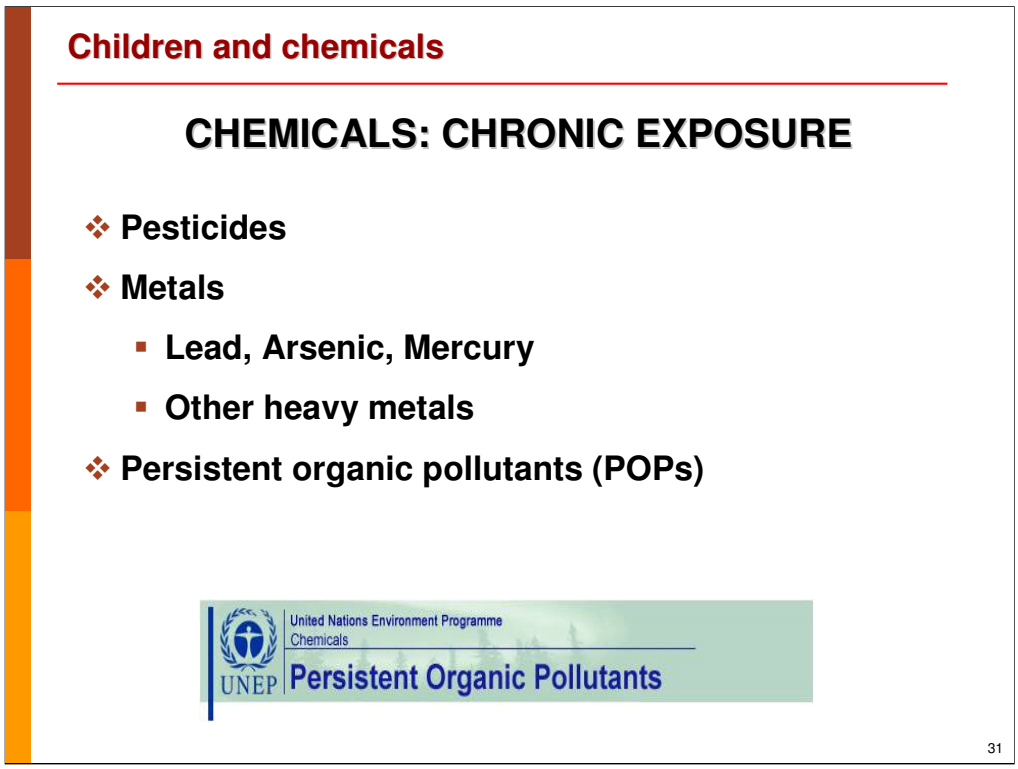
Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health, 2nd edition. Etzel RA, Balk SJ, eds. Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•European Union. Volatile organic compounds (VOCs). Available at *www.environ.ie/en/Environment/Atmosphere/AirQuality/VolatileOrganicCompounds/* - accessed March 2011

•WHO. Air quality and health. Fact sheet 313, *WHO*, 2008 – available at www.who.int/mediacentre/factsheets/fs313/en/ - accessed March 2011

Image: United States Environmental Protection Agency. "Applying insect repellent". Copyright notice: works produced by the U.S. Government are in the public domain.



<< NOTE TO USER: for each type of chemical mentioned, describe examples of chronic exposure that are pertinent to the area and/or your personal experience on the subject.>>

Although any chemical can cause acute toxic exposure, in some instances low-level, chronic exposures are a cause of concern. They are difficult to diagnose and require very careful historical examination. Acute poisonings are usually considered as the "tip of the iceberg" and it is the chronic, low dose mixed exposure over generations that may be doing harm that we don't yet understand properly.

•Lead is associated with neurodevelopmental delay.

•Arsenic in well water at low level chronic exposure has been associated with skin cancer, bladder cancer, lung cancer, hypertension, diabetes, anaemia, peripheral neuropathy.

•Mercury is also associated with neurodevelopmental effects and may be present in paints, antiseptics, and certain fish.

•Pesticides may be present in fields, in food, or in water runoff which may be used for drinking and cooking. Some pesticides have been associated with neurological and immunologic effects.

•Persistent organic pollutants (POPs) can cause exposure via food and water. This group of substances have been linked to a variety of health effects including dermatologic effects, endocrine effects, immunologic effects, and cancer)

Little work has been done on understanding the toxicity of metabolites, environmental degradation from synthetic chemicals singly or in mixtures or multigenerational exposures. Early experience indicates that children including the fetus will often be harmed disproportionately and more severely than adults by exposure to many of these chemicals. The release into the environment of large numbers and varieties of manmade chemicals may come back to haunt us as diseases and disabilities in our children and grandchildren. We are seeing in wildlife populations evidence of immune diseases, endocrine disruption, birth defects and declining populations which may be related to chemical pollution. Dr. Herb Needleman has warned that we are performing a vast uncontrolled experiment with our children as subjects and indeed Theo Colburn, a wildlife biologist with World Wildlife Federation (WWF), and author of Our Stolen Future suggests the same with this concept of the generations.

The list includes types of chemicals involved in chronic, high-level and low-level exposures for which important adverse effects in children have been demonstrated and/or that represent a potential threat (e.g. persistent organic pollutants).

HCB: hexacholorobenzene; **HCH**: hexachlorocyclohexane; **PCBs**: polychlorinated biphenyls; **DDT**: dichlorodiphenyltrichloroethane; **PBDEs**: polybrominated diphenyl ethers

Refs:

•Stockholm Convention on Persistent Organic Pollutants. Available at *chm.pops.int/Home/tabid/36/language/en-US/Default.aspx* – accessed March 2011.

Initial 12 POPs

Initially, 12 POPs have been recognized as causing adverse effects on humans and the ecosystem and these can be placed in 3 categories:

- Pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene;

- Industrial chemicals: hexachlorobenzene, polychlorinated biphenyls (PCBs); and

- By-products: hexachlorobenzene; polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF), and PCBs.

Nine new POPs

At its fourth meeting held from 4 to 8 May 2009, the Conference of the Parties (COP) adopted amendments to Annexes A (elimination), B (restriction) and C (unintentional production) of the Stockholm Convention to list 9 additional chemicals as persistent organic pollutants.

- Pesticides: chlordecone, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, lindane, pentachlorobenzene;

- Industrial chemicals: hexabromobiphenyl, hexabromodiphenyl ether and heptabromodiphenyl ether, pentachlorobenzene, perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride, tetrabromodiphenyl ether and pentabromodiphenyl ether; and

- By-products: alpha hexachlorocyclohexane, beta hexachlorocyclohexane and pentachlorobenzene.

•Webster P. Persistent toxic substances: study finds heavy contamination across vast Russian Arctic. *Science*, 2004, 306:1875.

•WHO. Childhood lead poisoning. *WHO*, 2010. Available at *www.who.int/ceh/publications/childhoodpoisoning/en/index.html* - accessed March 2011.

•WHO. Children's exposure to mercury compounds. *WHO*, 2010. Available at *www.who.int/ceh/publications/children_exposure/en/* - accessed March 2011.

•WHO. Persistent organic pollutants: impact on child health. WHO, 2010. Available at *www.who.int/ceh/publications/persistent_organic_pollutant/en/index.html* - accessed March 2011.

•WHO/UNEP/ILO. Guidelines on the prevention of toxic exposures: education and public awareness activities. *WHO*, Geneva, 2004.

Children and chemicals

PESTICIDES: CHRONIC EXPOSURE

WHO

- Child-care centres
- Schools
  - Children spend hours
  - Close to the ground
  - Touching and tasting
  - Pesticides applied remain in carpets and fabrics.

- ✓ Levels of chlorpyrifos vapours in the child's breathing zone (25 cm) are 94 microg/m^3 but in the adult's breathing zone (100 cm) are 64 microg/m^3
- ✓ Exposure of neonatal rats to chlorpyrifos produced brain cell damage and loss, with resultant abnormalities of synaptic development.

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This slide illustrates how exposure may occur, for example in a toddler, in the special settings of the child-care centre, where carpets and fabrics may have been sprayed with pesticides.

Small children have special susceptibilities to exposure because of their:
- hand-to-mouth behaviour;
- ignorance of risks;
- being close to the ground while playing, crawling or sleeping;
- behavior as explorers and investigators (touching and tasting).

Studies on the pesticide chlorpyrifos, an organophosphorus compound that has been used in schools and homes, showed that it has a special volatility and re-evaporation cycle that allows the vapours to concentrate more about 25 cm from the floor (in the child's breathing zone) than in the adult's breathing zone (about 100 cm for a seated adult). The levels of chlorpyrifos measured were 94 microg/m^3 in the child's breathing zone and 64 microg/m^3 in the adult's breathing zone.

Experiments with neonatal rats showed that chlorpyrifos produced brain cell damage and loss, with resultant abnormalities of synaptic development.

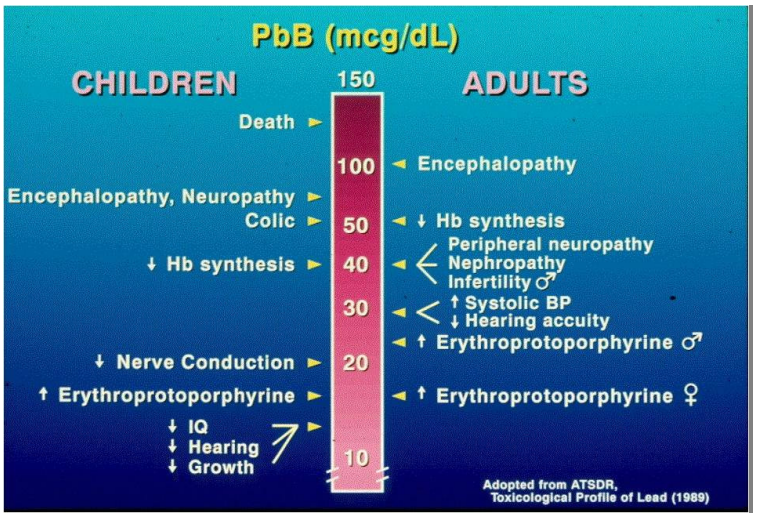
Ref:

•Qiao D et al. Developmental neurotoxicity of chlorpyrifos: what is the vulnerable period? *Environmental Health Perspectives*, 2002, 110(11):1097.

•FAO/UNEP/WHO. Childhood pesticide poisoning: Information for advocacy and action. *FAO/UNEP/WHO*, 2004. Available at *www.who.int/ceh/publications/pestipoison/en/* - accessed March 2011.

Children and chemicals

LEAD TOXICITY: CHRONIC EXPOSURE



Agency for Toxic Substances and Disease Registry

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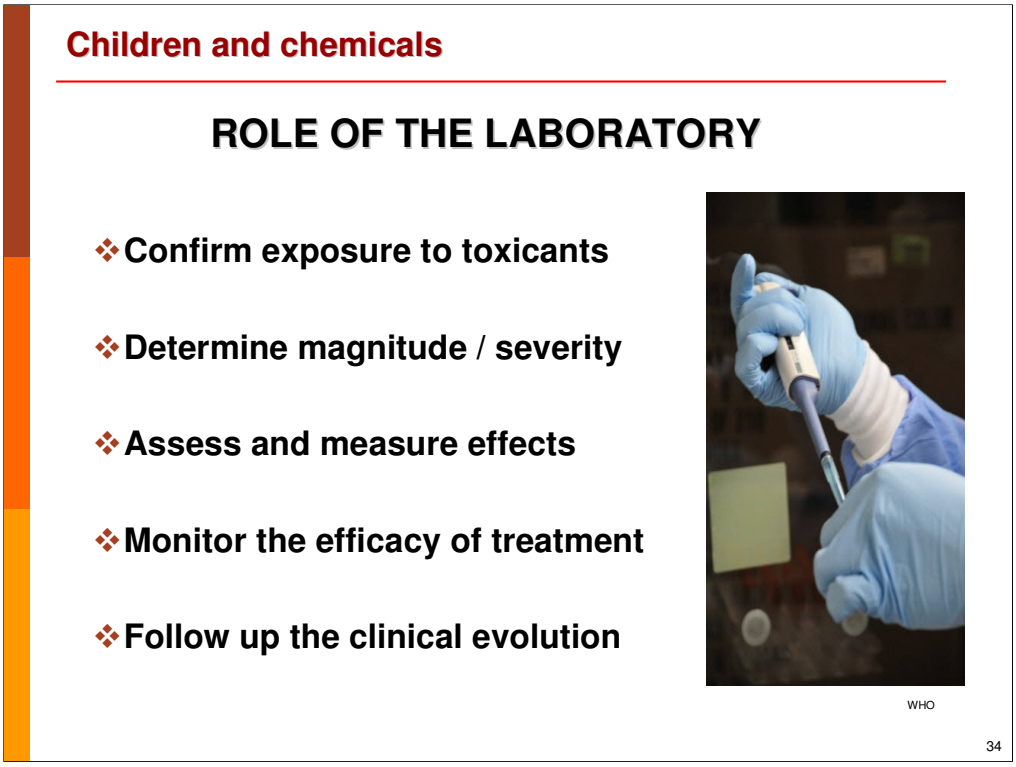
The threshold for the various effects of lead poisoning in children is generally lower than in adults. The *ATSDR (Agency for Toxic Substances and Disease Registry)* has created this scheme in which symptoms and abnormal laboratory tests are plotted against blood lead levels (PbB) for children (left side) and for adults (right side).

<< NOTE TO USER: Mention local regulation to lead levels and/or your personal experience on the subject.>>

Ref:

•Centers for Disease Control and Prevention. Case studies in environmental medicine (CSEM). Lead toxicity
Key concepts. In: *Agency for Toxic Substances and Disease Registry*, 2007. Available at *www.atsdr.cdc.gov/csem/lead/pbcover_page2.html* – accessed May 2011.

Image: Centers for Disease Control and Prevention. Case studies in environmental medicine (CSEM). Lead toxicity
Key concepts. In: Agency for Toxic Substances and Disease Registry, 2007. Available at www.atsdr.cdc.gov/csem/lead/pbcover_page2.html – accessed May 2011. Copyright notice: this image accessed May 2011 is in public domain.



Laboratory studies are important in the area of paediatric toxicology in order to:

❖confirm exposure (detecting levels in biological fluids);

❖determine the magnitude and severity of exposure;

❖assess and measure effects (e.g. levels of anemia, cholinesterase inhibition, other);

❖monitor the efficacy of treatment;

❖follow up the clinical evolution.

Unfortunately, only the minority of exposures can be measured, understood and treated. Specific analyses are not usually available in general hospitals, mostly in developing countries. Prevention and precaution are the important key for avoiding effects of chemical exposures.

<< NOTE TO USER: Mention examples that are pertinent to the area and/or your personal experience on the subject.>>

Suggested examples:

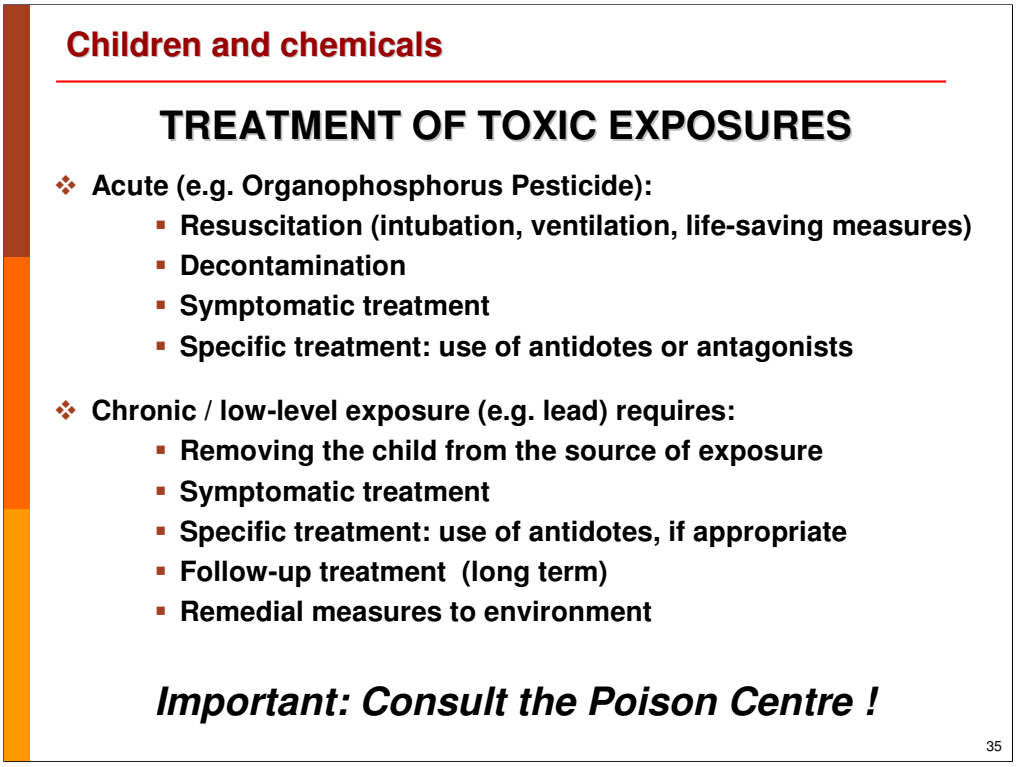
-Lead exposure – measuring blood lead levels

-Exposure to organophosphorus pesticides – confirmation by measurement of cholinesterase in red blood cells or whole blood.

Ref:

•American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health, 2nd edition. Etzel RA, Balk SJ, eds. Elk Grove Village, IL: American Academy of Pediatrics, 2003.

Image: WHO



The treatment of toxic exposures in children varies according to the chemical involved, the type/level of exposure, the clinical effects observed and also according to the results of laboratory studies.

<< NOTE TO USER: Mention one or two examples of acute and chronic exposures to illustrate how treatment differs.>>

Specific examples

Organophosphorus (OP) pesticide

Acute poisoning by an organophosphorus pesticide may require decontamination (washing of the skin, or possibly gastric lavage, under special circumstances), drying bronchial hypersecretion with atropine and the administration of enzyme reactivators (pralidoximes).

Lead

Chronic lead exposure requires removal of the child from the source of exposure (e.g. contaminated soil or water, paint chips in the home, stopping use of leaded ceramics) and personal and home hygiene measures. Environmentally-exposed children may have a blood lead level of around 10–15 microg/dL. If blood lead levels are above 45 microgram/dL, the use of a chelating agent (succimer) should be considered. If the child presents with lead encephalopathy, intensive care is required as well as the administration of chelating agents.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health, 2nd edition. Etzel RA, Balk SJ, eds. Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•WHO/UNEP/ILO. Guidelines on the prevention of toxic exposures: education and public awareness activities. *WHO*, Geneva, 2004.

•Winneke G, Kramer U. Neurobehavioral aspects of lead neurotoxicity in children. *Central European Journal of Public Health*, 1997, 5:65.

Children and chemicals

PREVENTION OF EXPOSURE IS THE SINGLE MOST EFFECTIVE MEANS OF PROTECTING CHILDREN AGAINST TOXICANTS

Health care providers play a key role in:

- Identifying the problem
- Defining its determinants and characteristics
- Informing the community – and the children!
- Educating colleagues and other professionals
- Raising the awareness of policy-makers
- Promoting the implementation of the appropriate measures
- Helping to evaluate the efficacy of preventive measures

WHO

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<< NOTE TO USER: mention success stories of prevention of toxic exposures and exposure to pollutants. Give examples that are pertinent to the area and/or your personal experience on the subject.>>

Health care providers play a key role in many aspects of the prevention of exposure. These are:

•*Identifying the problem*. What are the main toxic exposures in children? What are the main causes of acute poisonings? Are there any cases of chronic exposure to environmental pollutants? Is there a high incidence of diseases that may be linked to chemicals in the environment? Paediatric hospitals and poisons centres may be able to provide statistical and epidemiological data on the subject.

•*What are the determinants and characteristics?* Are exposures in children acute or chronic? Where do they occur? When and how? Are there any predisposing factors? Which populations or groups are affected? Are they predominantly urban or rural?

•*Informing the community – and the children*! The community whose children are exposed to chemicals and pollutants in the environment should be informed about the situation in a clear manner (*do not hide!...do not scare!)*. Social workers and communications experts may provide valuable advice on how to communicate risks or potential threats to the community, and how its members may avoid them and protect their children.

•*Educating colleagues and other professionals*. It is especially important to educate those who should recognize and manage the effects of chemicals on children's health (e.g. nurses, physicians, primary health care workers). Those who will help in assessing environmental issues should also be educated.

•*Raising the awareness of policy-makers about the problems identified*. Policy-makers should be made aware of the risks facing children – poisonings and potential chronic exposures.

•*Promoting the implementation of the appropriate actions*. The implementation of the appropriate measures should be promoted in consultation with key partners including policy-makers, doctors, nurses, teachers and parents.

•*Evaluating the efficacy of preventive measures.* The efficacy of preventive measures should be evaluated and the community should be informed of the findings!

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health, 2nd edition. Etzel RA, Balk SJ, eds. Elk Grove Village, IL: American Academy of Pediatrics, 2003.

•Boese-O'Reilly S, Shimkin M. Taking action to protect children from environmental hazards. In: *Children's health and the environment: a global perspective*. Pronczuk J, ed. WHO, Geneva, 2005:253-272.

•IFCS. Chemical safety and children's health: Protecting the world's children from harmful chemical exposures: a global guide to resources. *IFCS*. Available at *www.who.int/ifcs/champions/booklet_web_en.pdf* – accessed March 2011

•WHO. Principles for evaluating health risks in children associated with chemical exposure. Environmental Health Criteria 237. *WHO*, Geneva, Switzerland, 2006. Available at *www.who.int/ipcs/publications/ehc/ehc237.pdf* – accessed March 2011

•WHO/UNEP/ILO. Guidelines on the prevention of toxic exposures: education and public awareness activities. *WHO*, Geneva, 2004.

Image: WHO, South-East Asia Regional Office.

Children and chemicals

CASE STUDY: THAI SCHOOLCHILDREN AND PESTICIDES

- Schools aim to identify toxic pesticides available in the farming communities and the hazardous uses
- Children also assess the acute health effects suffered by their parents by conducting a health history and examination before and after spraying.
- Goal is to raise awareness among children and their parents about the hazards of pesticides and to eliminate exposure and the resulting adverse health effects

The Thai Education Foundation, with support from the community Integrated Pest Management (IPM) programme of the Food and Agriculture Organization of the United Nations has been testing an innovative strategy to raise awareness of these hazards among the rural population. Schools aim to identify the toxic pesticides available in the farming communities, and the hazardous ways of applying, storing and discarding them. The children also assess the acute health effects suffered by their parents by conducting a health history and examination before and after spraying. The goal is to raise awareness among children and their parents about the hazards of pesticides and to eliminate exposure and the resulting adverse health effects.

This is an example of nonformal discovery learning, which is highly relevant for children. This powerful educational method stimulates observation and communication skills, involves mathematics and art, and promotes critical thinking. Furthermore, students act as agents for change in the community as well as child-to-child and child-to-parent educators. Although the data are not validated by outside specialists, they illustrate the hazards of pesticide use in a rural farming community. This methodology can be applied to a range of other public health issues that require change in behaviour based on community data. For instance, surveillance of diarrhoea incidence, with promotion of hand-washing or food safety, monitoring of indoor air, and immunization coverage or campaigns are activities in which schoolchildren could be involved.

Ref:

•Wichanee S et al. Health hazards of pesticide use: Studies by Thai schoolchildren. In: *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.

Children and chemicals

CASE STUDY: THAI SCHOOLCHILDREN AND PESTICIDES

Results:

- Household pesticide storage and disposal practices improved.
- Initially, students identified that pesticides were stored in areas where children played
- After 4 months, the proportion of houses defined as “child unsafe” had decreased from 64% to 45%.
- Pesticide storage and disposal that were potentially contaminating food, water and livestock improved by 31%, 22%, and 20%respectively.
- Homes recycling pesticide containers diminished from 16% to 5%.
- Students reported that their parents took greater care to protect themselves during spraying. All wore rubber gloves and boots and none smoked during the spray operation.
- Of the 18 signs and symptoms of health effects initially reported by parents, all but two decreased in frequency.

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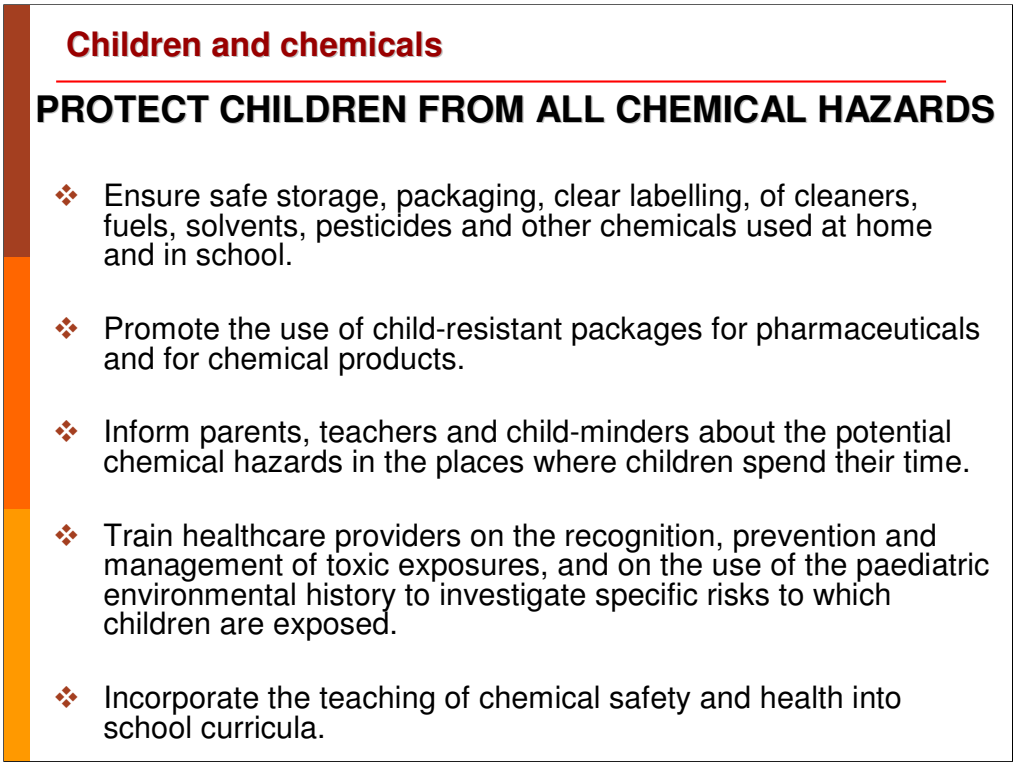
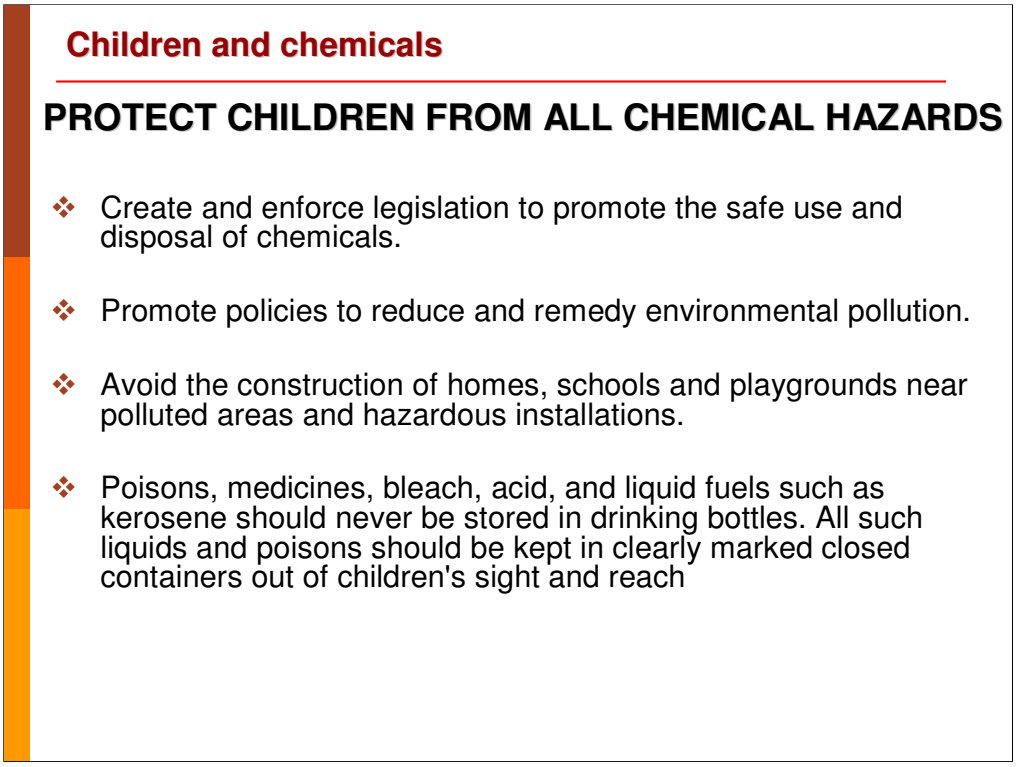


- Ensure safe storage and packaging, and clear labelling, of cleaners, fuels, solvents, pesticides and other chemicals used at home and in school.
- Promote the use of child-resistant packages for pharmaceuticals and for chemical products.
- Inform parents, teachers and child-minders about the potential chemical hazards in the places where children spend their time.
- Train healthcare providers on the recognition, prevention and management of toxic exposures, and on the use of the paediatric environmental history to investigate specific risks to which children are exposed.
- Incorporate the teaching of chemical safety and health into school curricula.

Ref:

- WHO. *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.
- WHO/UNEP. Healthy environments for healthy children. Key messages for action. *WHO*, Geneva, 2010. Available at www.who.int/ceh/publications/hehc_booklet/en/index.html – accessed May 2011.

<< NOTE TO USER: More information on taking the environmental history is available in the Pediatric Environmental History module>>



- Create and enforce legislation to promote the safe use and disposal of chemicals.
- Promote policies to reduce and remedy environmental pollution.
- Avoid the construction of homes, schools and playgrounds near polluted areas and hazardous installations.
- Poisons, medicines, bleach, acid, and liquid fuels such as kerosene should never be stored in drinking bottles. All such liquids and poisons should be kept in clearly marked closed containers out of children's sight and reach

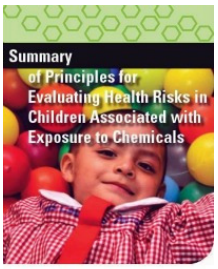
Refs:

- WHO. *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.
- WHO/UNEP. Healthy environments for healthy children. Key messages for action. *WHO*, Geneva, 2010. Available at www.who.int/ceh/publications/hehc_booklet/en/index.html – accessed May 2011.

Children and chemicals

PROTECT CHILDREN FROM ALL CHEMICAL HAZARDS
WHO TOOLS AVAILABLE
www.who.int/ceh

- Publications for all audiences: health professionals, scientists, policy-makers, communities
  - www.who.int/ceh
  - www.who.int/ipcs/en/
- *Summary of Principles for Evaluating Health Risks in Children Associated with Exposure to Chemicals*
- Training package on child health and environment
- Birth cohort studies initiative
- National profiles on child health and environment
- Pediatric environmental health history
- UNEP/WHO Toxicology in the classroom toolkit for schoolchildren
  - www.chem.unep.ch/Pesticides/ToxicologyInTheClassroom/default.htm



www.who.int/ceh

Refs:

•WHO. *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.

•WHO/UNEP. Healthy environments for healthy children. Key messages for action. *WHO*, Geneva, 2010. Available at www.who.int/ceh/publications/hehc_booklet/en/index.html – accessed May 2011.

•WHO. Summary of Principles for Evaluating Health Risks in Children Associated with Exposure to Chemicals. WHO, 2011. Available at *www.who.int/ceh/publications/health_risks_exposure_chemicals/en/index.html* - accessed October 2011.

A number of international recommendations and agreements refer to the protection of children's health from the effects of chemicals. Listed here are some examples.

<<NOTE TO USER: Mention the agreements that are relevant to the setting of the course and participants, and mention those ratified and/or followed-up in the country.>>

Ref:

•WHO. *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.

<<NOTE TO USER: Mention the agreements that are relevant to the setting of the course and participants, and mention those ratified and/or followed-up in the country.>>

Ref:

•WHO. *Children's Health and the Environment: a global perspective*. ed: Pronczuk J. WHO, Geneva, 2005.

WERE THE LEARNING OBJECTIVES REACHED?

- Learn about chemical hazards in children – what they are and what are the risks they may pose?
- Identify the scenarios – how, where and when are children exposed?
- Recognize signs, symptoms and diseases that may be related to acute and chronic toxic exposures in children
- Know how to assess, prevent and manage children's toxic exposures

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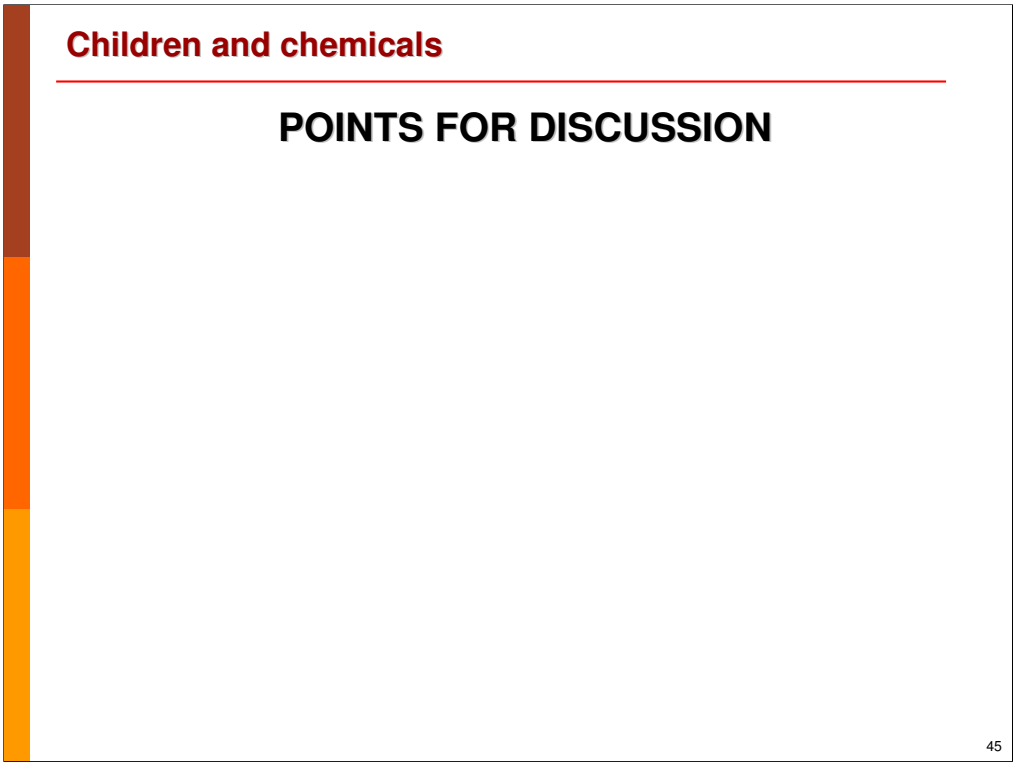
<< NOTE TO USER: Go through the learning objectives summarizing what has been presented and checking whether the objectives were accomplished.>>

<< NOTE TO USER: More information on specific chemicals is available in other modules (e.g.: lead, mercury, pesticides, heavy metals, etc.) Please check the list available on the website www.who.int/ceh>>



<<NOTE TO USER: Add points for discussion according to the needs of your audience.>>

Children and chemicals

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Latest update: October 2011 (H. Graczyk, L. Tempesta)

Children and chemicals

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