

Indoor Air Pollution and Children's Environmental Health

TRAINING FOR THE HEALTH SECTOR



INDOOR AIR POLLUTION

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.>>

<<NOTE TO USER: A number of slides (slide numbers 18 to 22) refer to the specific issues related to indoor air pollution in developing countries, as it represents a major determinant of the burden of disease in children. Please select slides and adapt the presentation to the specific needs of the country and your audience.>>

**This module is based on the WHO module "Indoor air pollution".
First draft prepared by Ligia Fruchtengarten MD (Brazil)**

Indoor Air Pollution and Children's Environmental Health

LEARNING OBJECTIVES TO UNDERSTAND, RECOGNIZE AND KNOW

- ❖ **The hazards of indoor air to children's health**
- ❖ **The sources for different toxicants in indoor air, according to different settings and activities**
- ❖ **The different characteristics and issues relating to indoor air pollution in industrialized and developing countries**
- ❖ **How to recognize, assess and address health effects**
- ❖ **How to prevent exposure to indoor air contaminants**

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<<READ SLIDE>>

<<NOTE TO USER: The indoor contaminants addressed in this module include:

- **Particulate matter**
- **Carbon monoxide**
- **Second-hand tobacco smoke**
- **Pesticides**
- **Solvents**
- **Volatile organic compounds**
- **Biological pollutants**
 - **Mites**
 - **Allergens**
 - **Mould**
- **Built environment**
- **Radon**
- **Asbestos**
- **Occupation-related contaminants**

When selecting your slides, please present only those of relevance to the country and/or the interests of your audience.>>

Indoor Air Pollution and Children's Environmental Health

DIFFERENT AND UNIQUE EXPOSURES

Unique pathways: trans-placental, breast-milk
Child behaviors: "hand-to-mouth", touching, testing,..
Environments: living-zones, micro-environments
Inability to understand danger (infants to adolescents)

DYNAMIC, DEVELOPMENTAL PHYSIOLOGY

Increased nutrient and energy requirements
"Anabolic" Absorption, Biotransformation, Distribution, Elimination
Special susceptibility: "Critical windows of vulnerability"

LONGER LIFE EXPECTANCY

POLITICALLY POWERLESS

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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 often receive 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.

CHILDREN'S UNIQUE VULNERABILITY

- ❖ Inhale more pollutants per kilogram of body weight than do adults
- ❖ Because airways are narrower, irritation can result in proportionately greater airway obstruction



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Infants and young children have a higher resting metabolic rate and rate of oxygen consumption per unit body weight than adults because they have a larger surface area per unit body weight and because they are growing rapidly. Therefore, their exposure to any air pollutant may be greater.

In addition to an increased need for oxygen relative to their size, children have narrower airways than do adults. Thus, irritation caused by air pollution that would produce only a slight response in an adult can result in potentially significant obstruction in the airways of a young child.

Ref:

- Moya. Children's behavior and physiology and how it affects exposure to environmental contaminants. *Pediatrics*, 2004, 113:996.

SMALLER AIRWAYS MORE VULNERABLE

Diagram of the Effect of Edema on the
Cross-Sectional Airway Diameter
(R = radius)

Adult Airway



$$\text{Area} = \pi R^2 = \pi 10^2 = 100 \pi \text{ mm}^2 \text{ (Normal)}$$

$$\text{If have 1 mm Edema} \quad \text{Area} = \pi 9^2 = 81 \pi \text{ mm}^2$$

or 81% of normal

Full Term Newborn



$$\text{Area} = \pi R^2 = \pi 3^2 = 9 \pi \text{ mm}^2 \text{ (Normal)}$$

$$\text{If have 1 mm Edema} \quad \text{Area} = \pi 2^2 = 4 \pi \text{ mm}^2$$

or 44% of normal

www.vh.org/pediatric/provider/pediatrics/ElectricAirway/Diagrams/AirwayDiameterEdema.jpg

The effect of oedema on the adult airway is much less dramatic than it is on the newborn's airway. One millimetre of oedema reduces the diameter of the adult airway by about 19% whereas it reduces the diameter of the infant airway by 56%.

Compared to that of adults, the peripheral airway (bronchioles) is both relatively and absolutely smaller in infancy allowing intraluminal debris to cause proportionately greater obstruction. In addition, infants have relatively larger mucous glands, with a concomitant increase in secretions. They also have the potential for increased oedema because their airway mucosa is less tightly adherent. Lastly, there are fewer interalveolar pores (Kohn's pores) in the infant, producing a negative effect on collateral ventilation and increasing the likelihood of hyperinflation or atelectasis.

The resting minute ventilation normalized for body weight in a newborn infant (400 cc/min/kg) is more than double that of an adult (150 cc/min/kg).


Ref: Bar-on. Bronchiolitis. *Prim Care*, 1996, 23:805.

Picture:

www.vh.org/pediatric/provider/pediatrics/ElectricAirway/Diagrams/AirwayDiameterEdema.jpg - Copyright protected material used with permission of the authors: Drs. Michael and Donna D'Alessandro - and the University of Iowa's Virtual Hospital, www.vh.org

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DEPOSITION OF POLLUTANTS IN RESPIRATORY TRACT



Water Solubility	Initial Level of Impact	Compounds
High	Eyes Nose Pharynx Larynx	Aldehydes Ammonia Chlorine Sulfur dioxide
Medium	Trachea Bronchi	Ozone
Low	Bronchioles Alveoli	Nitrogen dioxide Phosgene

CDC

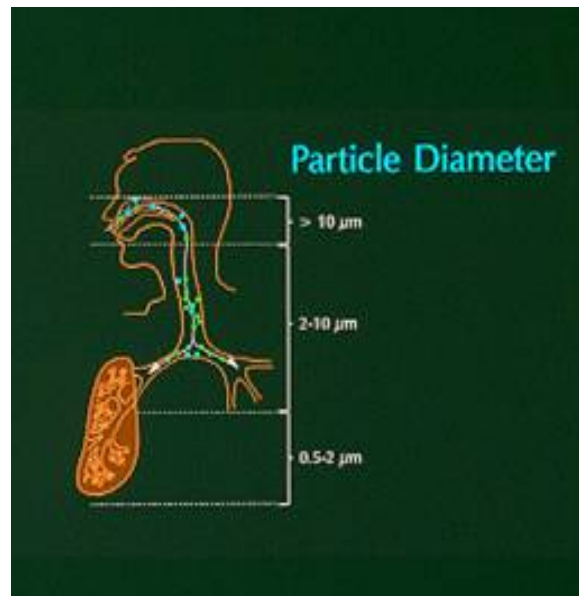
6

Respirable particles and gases affect different parts of the respiratory tree depending upon their inherent characteristics. For gases, relative solubility is important. For particles, size is important.

This slide shows the upper, middle and lower respiratory tract. Note that sulfur dioxide, because it is highly water soluble, initially affects the upper airway, whereas ozone, which has medium solubility, initially affects the middle airways, and nitrogen dioxide, which has low solubility, initially affects the lower airways.

SIZE MATTERS

- ❖ Coarse particles (2.5–10 microns) deposited in the upper respiratory tract and large airways
- ❖ Fine particles (< 2.5 microns) may reach terminal bronchioles and alveoli



Particle size is the most important factor in determining where particles are deposited in the lung.

Compared with large particles, fine particles can remain suspended in the atmosphere for longer periods and be transported over longer distances.

Some studies suggest that fine particles have stronger respiratory effects in children than large particles.

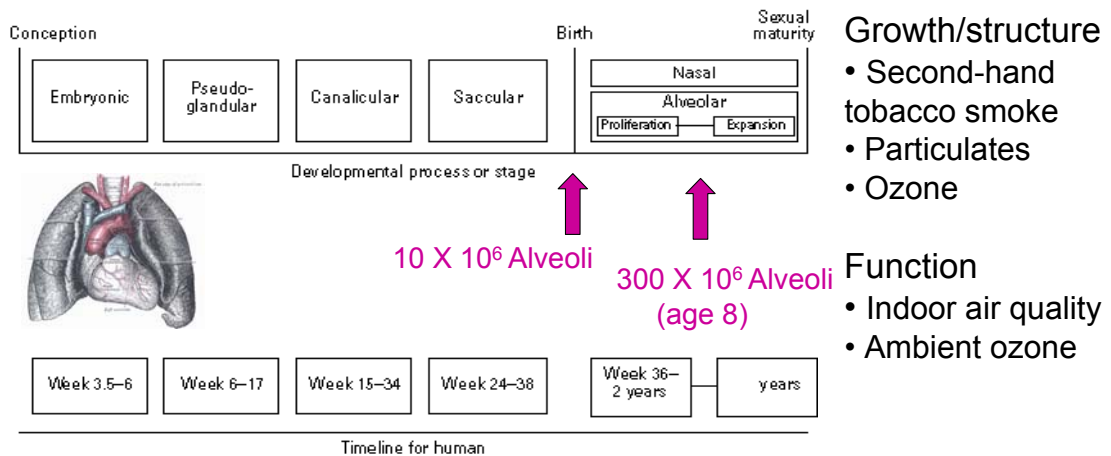
This diagram shows that particles greater than 10 microns rarely make it past the upper airways, whereas fine particles smaller than 2 microns can make it as far as the alveoli.

Ref:

•World Health Organization. *Air Quality Guidelines*. Geneva, World Health Organization: Department of Protection of the Human Environment, 1999.

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RESPIRATORY DEVELOPMENT: CONTINUES THROUGH LINEAR GROWTH



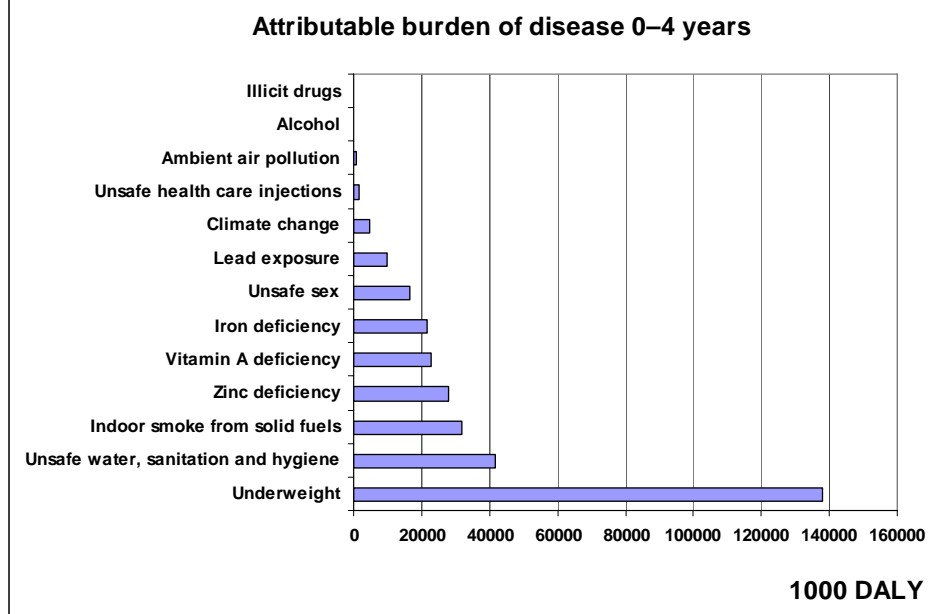
Dieter, 2000

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Like the nervous system, the respiratory system continues to grow and develop through linear growth. The upper section of the diagram depicts the different developmental phases of the lungs corresponding to the age of the embryo/fetus. It may be seen that at birth, a baby has about 10 million alveoli, but at age 8 years, the lungs have grown and the number of alveoli has reached 300 million. Exposures during this growth period are known to have adverse consequences on both structure (growth of the lungs, as illustrated in the diagram) and function (which is affected by indoor air quality and ozone exposure).

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

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World Health Report 2002

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In analyses by WHO in 2002, the indoor smoke from solid fuels accounted for the third highest disability-adjusted life year (DALY) for children 0 to 4 years of age.

The DALY is a health measure that incorporates loss of quality of life as well as loss of years of life. One DALY is the loss of one healthy life year.

Ref:

• *World Health Report 2002* (www.who.int/whr/2002/en/).

Picture: *World Health Report 2002*

CHILDREN'S INDOOR EXPOSURE

Level of economic development is a key factor

- ❖ Developing and industrialized countries
- ❖ Rural and urban areas
- ❖ Local climate
 - ⇒ architecture/ventilation

In urban areas, children may spend most of their time indoors.

⇒ most exposure to contaminants may come from air and environment inside homes and schools.



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The level of economic development is a key factor in determining children's exposures and the potential for responding to or improving their environment.

The level of social and economic development is linked closely to determinants of indoor air pollution (IAP).

There are major differences between developing and industrialized countries: IAP results from solid fuel use in the former, and from "chemicals" and "new substances" (e.g. formaldehyde, insecticides and phthalates) in the latter. However, second-hand tobacco smoke (SHTS) is a pollutant common to both settings.

IAP also differs between rural and urban areas due to the different economies and lifestyles. For example, dust and organic particles are more common in agricultural areas and mites or fungal contaminants in closed, unventilated urban dwellings.

The local climate conditions should also be taken into consideration, as they have an impact on architecture (building materials used, structure, room distribution and characteristics) and – particularly – on the ventilation of the dwelling.

Children in urban areas spend most of their time indoors, which means that their primary exposure to air pollution may come from air inside homes and schools rather than outdoors.

There are numerous situations in homes and schools which may result in possible exposure to contaminants, such as second-hand tobacco smoke, spraying of insecticides, accumulation of pollutants in carpets, poor quality air and others. Children may also be exposed where they play or at workplaces. The quality of children's environments can cause or prevent illness, disability and injury.

INDOOR AIR QUALITY

Indoor air quality is influenced by:

- ❖ Outdoor air pollution: vehicles and industrial plants
- ❖ Second-hand tobacco smoke (SHTS)
- ❖ Fuels used for heating and cooking
- ❖ Confined and poorly ventilated spaces
- ❖ Overcrowded homes and insufficient living space
- ❖ Customs, habits, traditions
- ❖ Level of economic development:
 - Industrialized ≠ developing countries

In summary, indoor air quality is influenced by concentrations of outdoor air pollutants, indoor sources of pollution, characteristics of the building and the habits of the residents.

Indoor air pollution may arise from the use of open fires, unsafe fuels or combustion of biomass fuels, coal and kerosene. Gas stoves or badly installed wood-burning units with poor ventilation and maintenance can increase the indoor levels of carbon monoxide, nitrogen dioxide and particles.

Other pollutants not associated with fuel combustion include building materials such as asbestos and cement, wood preservatives and others.

Volatile organic compounds may be released by various sources including paints, glues, resins, polishing materials, perfumes, spray propellants and cleaning agents. Formaldehyde is a component of some household products and can irritate the eyes, nose and airways.

CHILDREN'S INDOOR EXPOSURE

Time spent indoors is influenced by:

- ❖ Geographical region:
 - Seasons and temperature
 - Urban or rural area
- ❖ Level of development of of the region
- ❖ Cultural aspects
- ❖ Socioeconomic factors. For example...

<<NOTE TO USER: If you have local information on time spent indoors, please insert here.>>

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HOMES SHOULD BE HEALTHY PLACES



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The homes of poor children may be unhealthy places:

- 2 000 000 deaths from ARI in < 5 yr olds (½ due to solid fuel use)
- Rising trends of “wheezing”

- ❖ Coal and biomass fuel: a major source of indoor air pollution
- ❖ Suspended particulate matter increases the risk of acute respiratory infections
- ❖ CO and other toxic gases may impair development and health
- ❖ Second-hand tobacco smoke is a major concern

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The home is the first indoor environment a child will know. It should be a safe and healthy place.

<<READ SLIDE.>>

Picture: WHO, C. Gaggero. Child housework, Costa Rica.

ADVERSE HEALTH EFFECTS OF AIR POLLUTANTS

Acute:

- ❖ Irritation of the mucous membranes (eyes, nose, throat)
- ❖ Cough, wheeze, chest tightness
- ❖ Increased airway responsiveness to allergens
- ❖ Increased incidence of acute respiratory illness:
 - cold, pneumonia, otitis media
- ❖ Tracheobronchitis
- ❖ Exacerbation of asthma

<<READ SLIDE.>>

ADVERSE HEALTH EFFECTS OF AIR POLLUTANTS

Chronic:

- ❖ Long-term exposure decreases lung growth
- ❖ Impairment of pulmonary function
- ❖ Increased susceptibility to chronic obstructive lung diseases, including asthma

<<READ SLIDE.>>

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ENVIRONMENT AND POLLUTION

Indoor environments also reflect outdoor air quality

- ❖ Industrial or agricultural activities
- ❖ Treatment of industrial effluents and domestic residues
- ❖ Traffic
- ❖ Solid waste management
- ❖ Clandestine industries
- ❖ Chemical accidents and spills



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The indoor environment also reflects outdoor air quality and pollution. Outdoor pollution primarily results from the combustion of fossil fuels by industrial plants and vehicles. This releases carbon monoxide, sulfur dioxide, particulate matter, nitrogen oxides, hydrocarbons and other pollutants. The characteristics of emissions and solid waste disposal may vary for each specific industry (e.g. smelting, paper production, refining and others).

Picture: WHO, J. Vizcarra. Environmental Air Pollution

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INDOOR AIR POLLUTION ALSO AFFECTS OUTDOOR AIR QUALITY



Nigel Bruce/ITDG

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Indoor smoke polluting the ambient air in a small village in Nepal.

Picture: Nigel Bruce/ITDG. Used with permission.

COMBUSTION PRODUCTS

Combustion products

Carbon monoxide (CO)
Nitrogen dioxide (NO₂)
Sulfur dioxide (SO₂)
Nitrogenated compounds (Nx)
Particulate matter (PM)

Sources

Gas stoves and appliances
Wood and coal stoves
Gas and propane engines
Fireplaces
Tobacco smoke
Candles and incense
Mosquito coils

A large number of combustion products originate from various different sources. The main ones are listed here.

<<READ SLIDE.>>

SMOKY COOKING FUELS

Open fire cooking stoves produce heavy smoke containing:

- ❖ Fine particles
 - ❖ Carbon monoxide (CO)
 - ❖ Polycyclic aromatic hydrocarbons (PAHs)
-
- Strongly linked to pneumonia
 - Suggested link to low birth weight
 - In adults: chronic obstructive pulmonary disease, lung cancer



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Girls are at most risk as they are often requested to help their mothers with household chores. Infants are exposed to pollutants when carried on the backs of their mothers as they tend fires. Irritation that would not affect adults may result in severe obstruction or damage to children's lungs because they are more vulnerable.

Ref:

- Environmental threats to children. In: *Children in the New Millennium, Environmental Impact on Health*. UNEP, UNICEF & WHO, 2002.

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EVIDENCE FOR A HEALTH IMPACT

Health outcome	Population	Evidence
Acute respiratory infections (ARI)	Children < 5	Strong
Chronic obstructive pulmonary disease (COPD)	Women ≥ 15	Strong
Lung cancer (coal only)	Women ≥ 15	Strong
Tuberculosis	Women ≥ 15	Moderate
Blindness (cataracts)	Women ≥ 15	Moderate
Asthma	Children < 5	Weak
Low birth weight	Children < 1	Tentative
Perinatal mortality	Children < 1	Tentative
Otitis media	Children < 5	Tentative

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This table shows the different levels of evidence in relation to links between air pollution and child health. As seen in the table, the evidence is strong for three key diseases: acute respiratory infections, chronic obstructive pulmonary disease and lung cancer. This is based on a meta-analysis conducted by Smith, Mehta and Feuz.

Ref:

•Smith. Chapter 18: Indoor smoke from household use of solid fuels. In: Ezzati Eds. *Comparative quantification of health risks: The global burden of disease due to selected risk factors, Vol 2*. Geneva: World Health Organization, 2004 (www.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=554).

Indoor Air Pollution and Children's Environmental Health

HOUSEHOLD ENERGY, IAP AND HEALTH

- ❖ 3 billion people rely on solid fuels
- ❖ Solid fuels comprise 10--15% of the total fuels used worldwide
- ❖ Cooking and heating \Rightarrow
↑ levels indoor air pollution
- ❖ Most concern: particulate matter (PM₁₀) and carbon monoxide
- ❖ Women and children heavily exposed

Dung
Wood
Agricultural
residues
Charcoal
Coal



Nigel Bruce/ITDG

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Some 3 billion people (half of the world's population!) rely on solid fuels (e.g. dung, wood, agricultural residues, charcoal, coal) for their basic energy needs.

Cooking and heating with solid fuels leads to high levels of indoor air pollution (IAP), a complex mix of health-damaging pollutants (e.g. particulate matter and carbon monoxide).

Women and young children, who spend most time at home, experience the largest exposures and health burdens.

Picture: Nigel Bruce/ITDG. Used with permission.

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INDOOR AIR POLLUTION LEVELS ARE VERY HIGH



Nigel Bruce/ITDG

- ❖ Particulates 24 hr mean in biofuel using home: **1000+ $\mu\text{g}/\text{m}^3$**
- ❖ Can reach **10 000 $\mu\text{g}/\text{m}^3$ PM_{10}** (if using an open fire)
- ❖ EPA: **50 $\mu\text{g}/\text{m}^3$ PM_{10}** annual mean
- ❖ **Women and young children have greatest exposure**

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Standards and guidelines

EPA standards are illustrated here. $150 \mu\text{g}/\text{m}^3 \text{PM}_{10}$ is the 24-hour 99% percentile value, thus it should be exceeded only on 1% of occasions. The recommended annual mean limit is $50 \mu\text{g}/\text{m}^3 \text{PM}_{10}$ (PM_{10} are respirable particles $\leq 10 \mu\text{m}$ in diameter).

Levels of pollution in homes using biomass fuel

Numerous studies have shown that the levels of particulates are very high, with 24-hour means of around $1000 \mu\text{g}/\text{m}^3 \text{PM}_{10}$, and even exceeding $10\,000 \mu\text{g}/\text{m}^3 \text{PM}_{10}$ when sampling is carried out during use of an open fire. It is reasonable to compare the EPA recommended annual mean limit of $50 \mu\text{g}/\text{m}^3 \text{PM}_{10}$ with the typical 24-hour mean for a home in which biomass fuel is used, of $1000 \mu\text{g}/\text{m}^3 \text{PM}_{10}$ quoted, as this latter value is typical of the level every day (thus, annual mean levels can be expected to be around $1000 \mu\text{g}/\text{m}^3 \text{PM}_{10}$). This comparison shows that average pollution levels are around 20 times the EPA recommended limit.

Ambient pollution and personal exposure

Two important components are (a) the level in the home, and (b) the length of time for which each person in the home is exposed to that level. We know that typically women and young children (until they can walk), and girls (as they learn kitchen skills) are often exposed for at least 3–5 hours a day, often more. In some communities, and where it is cold, exposure will be for a much longer period each day.

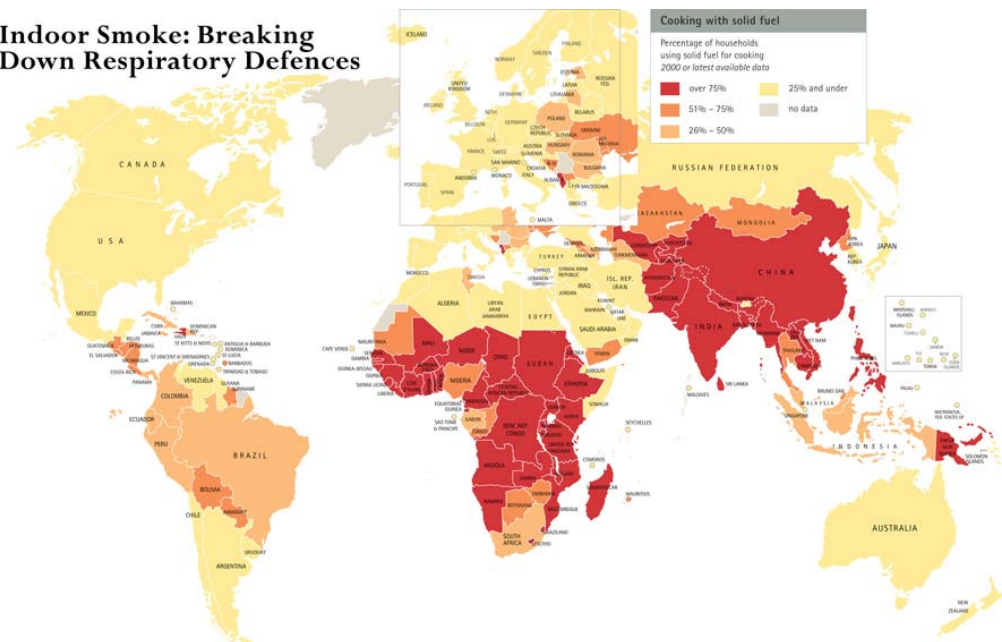
Ref: Addressing the links between indoor air pollution, household energy and human health. Based on the WHO-USAID Consultation on the Health Impact of Household Energy in Developing Countries (Meeting report). Geneva, World Health Organization, 2002.

Additional information can be found at: www.who.int/indoorair/publications/en/

Picture: Nigel Bruce/ITDG. Used with permission.

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Indoor Smoke: Breaking Down Respiratory Defences



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Cooking is central to our lives, yet the very act of cooking is a threat to children's health and well-being. Half of the world's population relies on solid fuels, such as dung, wood, crop waste or coal to meet their most basic energy needs. In most developing countries, these fuels are burned in open fires or rudimentary stoves that give off black smoke. Children, often carried on their mother's back during cooking, are most exposed. The indoor smoke inhaled leads to pneumonia and other respiratory infections – the biggest killer of children under 5 years of age. Indoor air pollution is responsible for nearly half of the more than 2 million deaths each year that are caused by acute respiratory infections. Good ventilation and improved cooking stoves can dramatically reduce children's exposure to smoke. Ultimately, making the transition to gas and electricity will save lives and reduce the physical toll on women and children from gathering wood, freeing time for education and development. This problem has been largely ignored by policy-makers.

Ref:

•Gordon. *Inheriting the world, the Atlas on Children's Health and the Environment*. Geneva, World Health Organization, 2004

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AGE DISTRIBUTION OF GLOBAL BURDEN OF DISEASE ATTRIBUTABLE TO SOLID FUEL USE

Age group (yrs)	Attributable mortality	Attributable DALYs
0-4	56	83
5-14	0	0
15-59	5	8
60+	38	9

Young children at high risk due to:

- ❖ The immaturity of their lungs
- ❖ Their high exposure to IAP: nearly 1 million children under 5 yrs die every year due to solid fuel use!



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Ref:

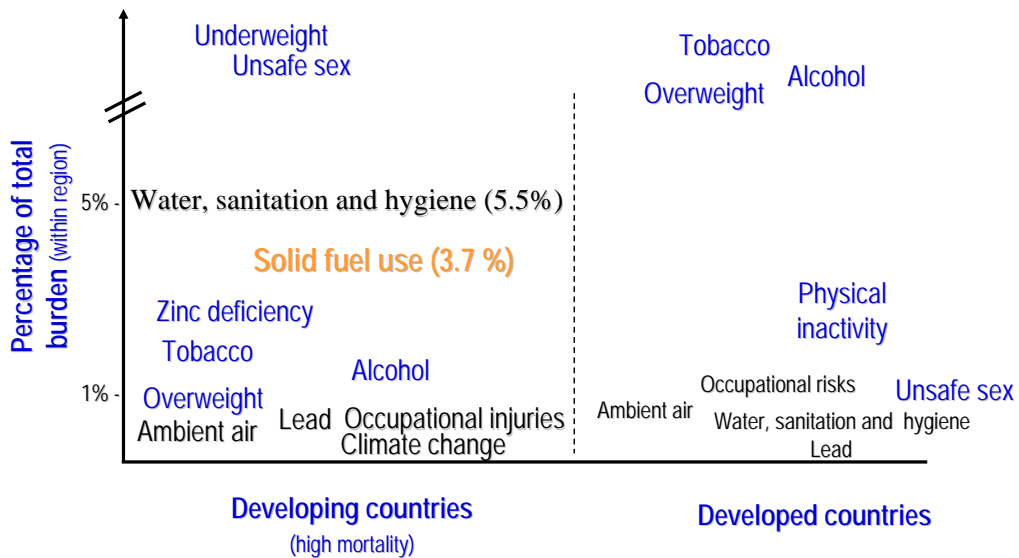
- *The health effects of indoor air pollution exposure in developing countries. Concise summary of the evidence for health effects of exposure to indoor air pollution from solid fuel use in children and adults.* Geneva, World Health Organization, 2002.

Additional information on these references can be found at:
www.who.int/indoorair/publications/en/

Picture: WHO. Americas.

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GLOBAL BURDEN OF DISEASE ATTRIBUTABLE TO SELECTED MAJOR RISK FACTORS



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Household energy practices vary widely around the world, as does the resultant death toll due to indoor smoke. In high-mortality developing countries, indoor smoke is responsible for 3.7% of the overall disease burden, making it the most important risk factor after malnutrition, unsafe sex and lack of safe water and adequate sanitation. In low-mortality developing countries, indoor smoke occupies the 8th rank and accounts for 1.9% of the disease burden. In contrast, in industrialized countries the impact of cooking and heating with solid fuels becomes negligible in relation to risk factors such as tobacco, high blood pressure and alcohol consumption. *Notes taken from www.who.int/indoorair/info/en/briefing2.pdf*

Refs:

- Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization*, 2000.
- *World Health Report 2002. Indoor Air Thematic Briefing 2* (www.who.int/indoorair/info/en/briefing2.pdf).

Additional information can be found at:
www.who.int/indoorair/publications/en/

WHAT INTERVENTIONS ARE AVAILABLE TO REDUCE INDOOR AIR POLLUTION FROM SOLID FUELS?

Source of pollution	Home environment	User behaviour
<ul style="list-style-type: none">❖ Improved stoves❖ Cleaner fuels (kerosene, gas, electricity)	<ul style="list-style-type: none">❖ Hoods and chimneys❖ Windows, ventilation holes, eaves spaces❖ Separate kitchen	<ul style="list-style-type: none">❖ Fuel drying❖ Use of pot lids❖ Good maintenance❖ Keeping children away from smoke

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- ❖ Solid fuels comprise only 10–15% of fuel used.
- Nearly one half of the world's population uses solid fuels for cooking and heating homes.
 - 2 billion people are exposed to PM and gases at levels up to 100 times higher than in ambient air.
 - Women and children are most exposed: levels may be 10 to 100 times above safety standards for ambient air.

❖ Combustion produces hundreds of toxic chemicals that concentrate inside homes.

Biomass (wood, agricultural produce, straw and dung) produces:

- a wide variety of liquids, suspended particles, gases and mixtures.

Coal produces:

- PAHs, benzene, formaldehyde, sulfur, heavy metals and fluoride.

These pollutants affect the most vulnerable populations, women of child-bearing age, infants and children in the poorest circumstances.

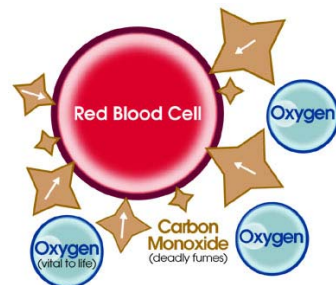
Ref: Air pollution: what a paediatrician needs to know. Leaflet published by the World Health Organization in collaboration with the International Pediatric Association, 2003.

Additional information on these references can be found at:

www.who.int/indoorair/publications/en/

CARBON MONOXIDE: THE "SILENT KILLER" A COMMON CAUSE OF ACUTE AND LETHAL POISONING

- ❖ Colourless, odourless gas formed by incomplete burning of carbon-based fuels
- ❖ CO's affinity for Hb is 240–270 times greater than oxygen
- ❖ Fetal Hb has higher affinity for CO
- ❖ CO causes a leftward shift of the oxyhaemoglobin (OHb) dissociation curve
- ❖ Intoxication results in tissue hypoxia
- ❖ Multiple organ systems are affected



www.cdc.gov/nceh/airpollution/carbonmonoxide/checklist.htm

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- CO is a colourless, odourless gas formed by incomplete burning of carbon-based fuels.
- CO's affinity for haemoglobin (Hb) is 240–270 times greater than that of oxygen:
 - it decreases the capacity of Hb for carrying oxygen.
- Fetal Hb has a higher affinity for CO.
- CO causes a leftward shift of the oxyhaemoglobin dissociation curve:
 - it decreases oxygen delivery to tissues.
- Intoxication results in tissue hypoxia.
- Multiple organ systems are affected:
 - Mainly systems with high metabolic rates;
 - CNS, cardiovascular system.

Exposure to carbon monoxide reduces the blood's ability to carry oxygen. The chemical is odourless and some of the symptoms of exposure are similar to those of common illnesses. This is particularly dangerous because carbon monoxide's deadly effects may not be recognized until it is too late to take action.

Exposure to carbon monoxide is particularly dangerous to unborn babies, infants and people with anaemia or a history of heart disease. Breathing low levels of the chemical can cause fatigue and increase chest pain in people with chronic heart disease. Breathing higher levels of carbon monoxide causes symptoms such as headaches, dizziness and weakness in healthy people. Carbon monoxide also causes sleepiness, nausea, vomiting, confusion and disorientation. At very high levels it causes loss of consciousness and death. Poisoning may have irreversible sequelae.

These notes are taken from the US EPA website www.epa.gov/iaq/co.html

*Refs: Carbon monoxide. In: *Pediatric environmental health*, 2nd ed. American Academy of Pediatrics. 2003.*

Figure: www.cdc.gov/nceh/airpollution/carbonmonoxide/checklist.htm

CARBON MONOXIDE (CO): SOURCES

- ❖ Gas, kerosene, wood stoves and coal
- ❖ Room and water heaters
- ❖ Fireplaces, furnaces
- ❖ Leaking chimneys and vents
- ❖ Vehicle exhaust in closed garage
- ❖ Tobacco smoke



EPA

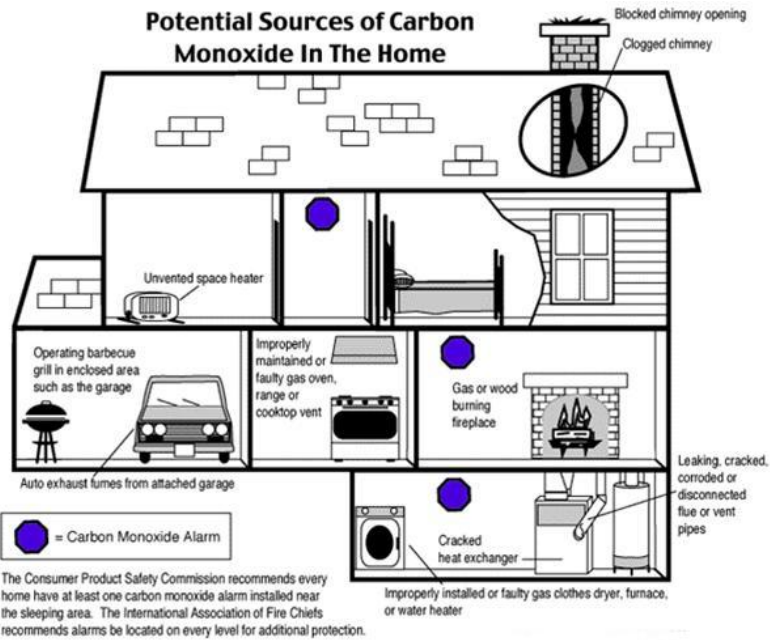
Any place where combustion is incomplete

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Incomplete oxidation during combustion in gas ranges and unvented gas or kerosene heaters may cause high concentrations of CO in indoor air. Worn or poorly adjusted and maintained combustion devices (e.g. boilers and furnaces) can be significant sources, especially if the fuel is of an unsuitable size, or if the system is blocked, or leaking. Car, truck, or bus exhaust from attached garages, nearby roads, or parking areas can also be a source. CO is one of the components of tobacco smoke.

Picture: www.epa.nsw.gov.au/woodsmoke/heateruse.htm

Indoor Air Pollution and Children's Environmental Health



In a typical single-family house, CO can come from many sources.

Figure: www.firstalert.com/index.asp?pageid=82, Used with Copyright permission.

PREVENTION OF EXPOSURE TO CO

- ❖ Keep fuel-burning appliances in good working condition
- ❖ Check heating systems, chimneys and vents regularly
- ❖ Never burn charcoal indoors
- ❖ Never leave a car running in a garage
- ❖ Install CO detectors

Prevention is the key to avoiding carbon monoxide poisoning.

Primary prevention of CO poisoning requires limiting exposure to known sources. Proper installation, maintenance, and use of combustion appliances can help to reduce exposure to CO.

The US EPA has set harm levels of:

- 50 ppm (8-hour average)
- 75 ppm (4-hour average)
- 125 ppm (1-hour average).

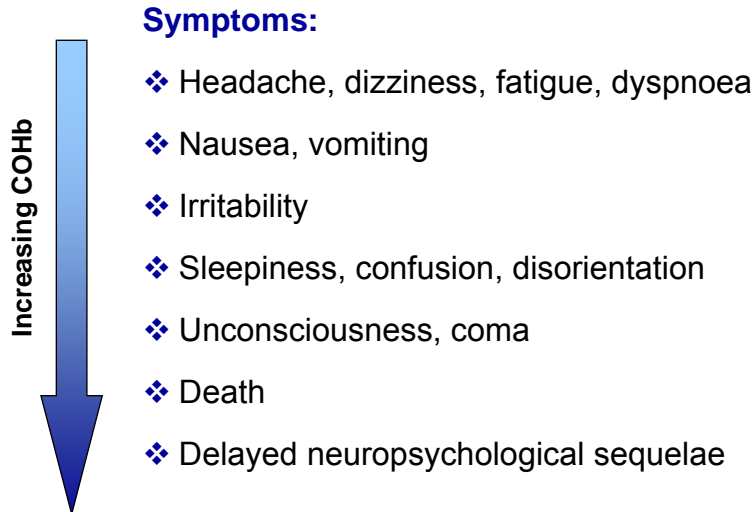
Exposure to these levels can lead to COHb levels of 5 to 10% and cause significant symptoms in sensitive individuals. The current air quality standards for CO, intended to keep COHb below 2.1%, recommend levels of not more than 9 ppm for 8 hours and 35 ppm for 1 hour for outdoor air. No standards for CO have been agreed for indoor air.

Smoke and CO detectors may provide early warning and prevent unintentional CO-related deaths.

Ref:

- www.pinefire-85.org/Fire_safety_pages/CARBON_MONOXIDE/carbon_monoxide.html

CARBON MONOXIDE POISONING CAN KILL



The route of exposure is through inhalation. Unintentional exposure to CO can be attributed to smoke inhalation from inadequately vented combustion appliances, and from vehicles and tobacco smoke.

The clinical features of CO poisoning are highly variable and symptoms vary from mild to very severe. Acute effects are due to the formation of carboxyhaemoglobin in the blood, which inhibits oxygen intake. At moderate concentrations, angina, impaired vision, and reduced brain function may result. At higher concentrations, exposure to CO can be fatal. Delayed neuropsychological sequelae have been reported in adults and children; these usually occur 3 to 240 days following exposure and are estimated to occur in 10 to 30% of victims.

Ref:

•California Poison Control System. *Poisoning and drug overdose*. Olson ed. Appleton and Lange, 1999.

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CARBON MONOXIDE POISONING CAN KILL

Diagnosis:

- ❖ Measurement of COHb
 - nonsmokers 1–3 %
 - smokers 3–8%
- ❖ Not useful:
 - Pulse oxymeter
 - Arterial blood gases

Treatment:

- ❖ Remove patient from CO source
- ❖ Life-support
- ❖ Oxygen 100%
- ❖ Hyperbaric oxygen
- ❖ Monitoring

The measurement of COHb confirms that exposure has occurred, but the severity of poisoning is not correlated to COHb levels.

Measurements of oxygen saturation by pulse oxymetry and arterial blood gas are not helpful for diagnosis because they are normal, although metabolic acidosis may be present. Normal levels of COHb range from 1 to 3% in nonsmokers and 3 to 8% in smokers.

Treatment of poisoning consists of supplemental oxygen, 100%, ventilatory support and monitoring cardiac dysrhythmias. Elimination half-life of COHb is approximately 4 hours in room air, 1 hour with provision of oxygen, 100%, and 20–30 minutes with hyperbaric oxygen.

Indoor Air Pollution and Children's Environmental Health

SECOND-HAND TOBACCO SMOKE (SHTS)

SCOPE OF THE PROBLEMS

Children whose mothers smoke:

- ❖ **70%** more respiratory problems
- ❖ Pneumonia and hospitalization in year 1 is **38%** higher
- ❖ Infant mortality is **80%** higher
- ❖ **20%** of all infant deaths could be avoided if all pregnant smokers stopped by the 16th week of gestation
- ❖ **5 times** higher risk of sudden infant death syndrome (SIDS)

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- ❖ Children whose mothers smoke have an estimated **70%** more respiratory problems than children whose mothers do not smoke.
- ❖ Pneumonia and hospitalization in the first year of life is **38%** more frequent in children whose mothers smoke.
- ❖ Infant mortality was **80%** higher in children born to women who smoked during pregnancy than in children of nonsmokers.
- ❖ An estimated **20%** of all infant deaths could be avoided if all pregnant smokers stopped by the 16th week of gestation.
- ❖ Infants of mothers who smoke have an almost **5 times** higher risk of sudden infant death syndrome (SIDS) than infants of mothers who do not smoke.

Smoke released from cigarettes, cigars and pipes is composed of more than 3800 different substances. Airborne particulate matter is 2–3 times higher in homes of smokers. Exposure may occur at home, school, in child care settings, in relatives' homes and other places. The importance of the need to reduce exposure to second-hand smoke justifies prohibiting smoking at home, in schools and in child care facilities.

SHTS is covered extensively in a separate module.

Refs: Etzel. Indoor air pollutants in homes and schools. *Pediatric Clinics of North America*, 2001, 48:1153.

• Wisborg. Exposure to tobacco smoke in utero and the risk of stillbirth and death in the first year of life. *American Journal of Epidemiology*, 2001, 154:322.

The authors examined the association between exposure to tobacco smoke in utero and the risk of stillbirth and infant death in a cohort of 25,102 singleton children of pregnant women scheduled to deliver at Aarhus University Hospital, Aarhus, Denmark, from September 1989 to August 1996. Exposure to tobacco smoke in utero was associated with an increased risk of stillbirth (odds ratio = 2.0, 95% confidence interval: 1.4, 2.9), and infant mortality was almost doubled in children born to women who had smoked during pregnancy compared with children of nonsmokers (odds ratio = 1.8, 95% confidence interval: 1.3, 2.6). Among children of women who stopped smoking during the first trimester, stillbirth and infant mortality was comparable with that in children of women who had been nonsmokers from the beginning of pregnancy. Conclusions were not changed after adjustment in a logistic regression model for the sex of the child; parity; or maternal age, height, weight, marital status, years of education, occupational status, and alcohol and caffeine intake during pregnancy. Approximately 25% of all stillbirths and 20% of all infant deaths in a population with 30% pregnant smokers could be avoided if all pregnant smokers stopped smoking by the sixteenth week of gestation.

CLINICAL EFFECTS OF SMOKE

- ❖ Respiratory tract illness
- ❖ Asthma
- ❖ Middle ear effusions
- ❖ Prenatal complications and low birth weight
- ❖ Fire-related injuries
- ❖ Sudden infant death syndrome (SIDS)
- ❖ Cancer

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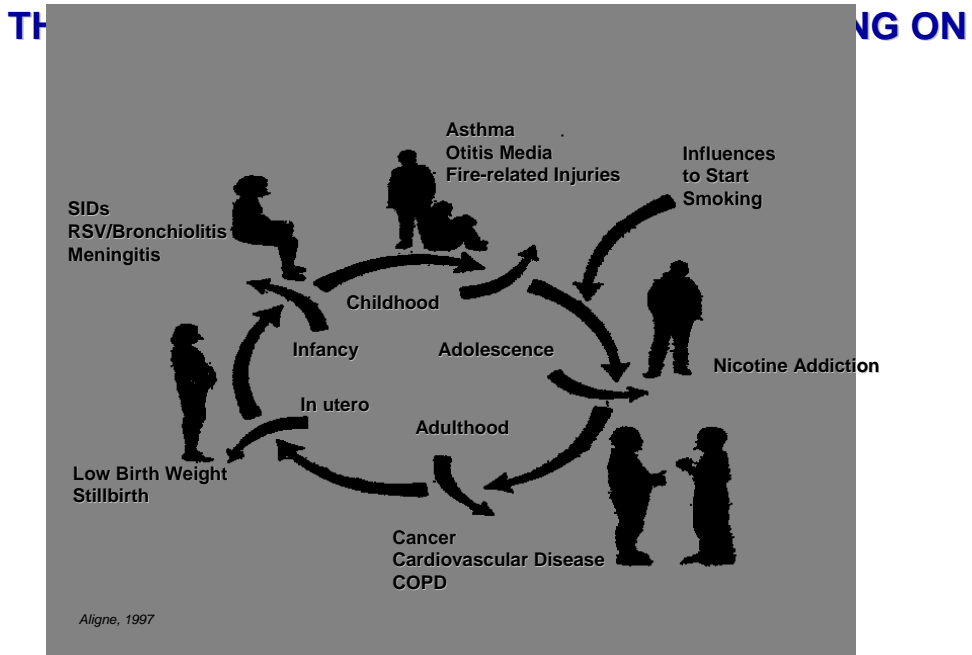
Asthma: a condition, often of allergic origin, that is marked by continuous or paroxysmal laboured breathing accompanied by wheezing, by a sense of constriction in the chest, and often by attacks of coughing or gasping.

Sudden infant death syndrome (SIDS): death of an apparently healthy infant, usually before the age of 1 year, that is of unknown cause and occurs especially during sleep.

Cancer: a malignant tumour of potentially unlimited growth that expands locally by invasion and systemically by metastasis.

Definitions taken from: medlineplus.gov

Indoor Air Pollution and Children's Environmental Health



This graphic depicts the life-cycle of the effects of tobacco smoking on health beginning *in utero* and continuing throughout adulthood. Pregnant women will have babies with lower birth weight as well as greater chances of stillbirth.

Children with parents who smoke will be more likely to develop respiratory problems, bronchiolitis, meningitis, asthma and otitis media and are at a higher risk of fire-related injuries. Furthermore, exposure to tobacco smoke damages the respiratory epithelium and decreases the ability to combat the respiratory syncytial virus (RSV), the leading cause of hospital admissions of children under 1 year of age.

Adolescence represents a high-risk period for taking up smoking behaviour.

As adults, children of smokers have a greater likelihood of developing cancer, chronic obstructive pulmonary disease (COPD) and cardiovascular diseases (CVD) than children with non-smoking parents. Also, children who have a parent who smokes are more likely to smoke as adults, so the cycle continues from one generation to the next.

Figure: Aligne. Tobacco and children: An economic evaluation of the medical effects of parental smoking. Arch Pediatr Adolesc Med, 1997, 151:652. Copyright (1997), American Medical Association. Used with permission.

PESTICIDES – EXPOSURE

- ❖ Problems of spraying pesticides at home and in schools
 - Higher concentrations near the floor
 - Persistence in some surfaces: carpets, soft toys, ...
 - Overuse and misuse of pesticides

- ❖ Children's behaviour and inhalation of pesticides
 - Crawling
 - Playing close to the floor
 - Hand-to-mouth
 - Object-to-mouth

Spraying pesticides in the home results in increased risks to children because of higher concentrations near the floor and persistence of insecticides in carpets and soft toys. The typical activities of young children also contribute to their higher exposure.

Pesticides are covered extensively in a separate module.

Ref:

•Reigart. Pesticides in children. *Pediatric Clinics of North America*, 2001, 48:1185.

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 neurodevelopmental effects are reviewed. Laws and regulations are also discussed.

Recommendations are made to pediatricians regarding treatment and advising families regarding avoidance of pesticide exposures and their effects.

PESTICIDES: INSECTICIDES

Classes commonly used for insect control indoors:

- ❖ Pyrethroids: allergenic, CNS toxicity at high levels
- ❖ Cholinesterase inhibitors: neurotoxicants, neurodevelopmental toxicants
- ❖ Hydramethylnone (relatively new)
- ❖ Insect repellents (DEET)
- ❖ Mosquito coils

Health effects:

- ❖ Acute poisoning usually related to accidental ingestion in children
- ❖ Allergic and general symptoms are common due to inhalation

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Classes of insecticide commonly used for insect control indoors include the following:

- *Pyrethroids*: these are very allergenic and can lead to CNS toxicity at high levels of exposure.
- *Cholinesterase inhibitors*: these are neurotoxicants and neurodevelopmental toxicants.
- *Hydramethylnone*: this is a relatively new insecticide.
- *Insect repellents*: diethyltoluamide (DEET).
- *Mosquito coils*.

The effects on health of exposure to these insecticides include:

- acute poisoning usually related to accidental ingestion in children;
- allergic and general symptoms (common results of inhalation)
 - headache, nausea, vomiting;
 - cough, rhinitis, bronchitis, asthma and other allergic symptoms.

MOSQUITO COILS

Household use in Africa, Asia, South America

- ❖ Major active ingredient – pyrethrins
- ❖ Long-term exposures linked to asthma and wheezing
- ❖ Smoke tested contained particulates, all < 1 micron



ehp.niehs.nih.gov/members/2003/6177/6177.html

Mosquito coils may represent a serious potential threat to children's health. Prolonged use has been associated with increased incidences of asthma and persistent wheezing in children. Although the active ingredient is usually small amounts of pyrethrins (considered a low-toxicity insecticide), over 99% of the mass of the coil is so-called "inert" ingredients. When analysed, the smoke from coils was found to be entirely composed of respirable-sized particles, some quite small. The particles contain numerous PAH and carbonyl compounds including formaldehyde. One recent analysis found that the burning of one mosquito coil for 2 hours allowed a steady state of particulate matter to develop, and that the PM_{2.5} produced was the equivalent of that from burning 75–137 cigarettes (the formaldehyde produced was the equivalent of 51 cigarettes).

Ref: Liu. Mosquito coil emissions and health implications. *Environ Health Perspect*, 2003, 111:1454.

Burning mosquito coils indoors generates smoke that can control mosquitoes effectively. This practice is currently used in numerous households in Africa, Asia and South America. However, the smoke may contain pollutants of health concern. We conducted the present study to characterize the emissions from four common brands of mosquito coils from China and two common brands from Malaysia. We used mass balance equations to determine emission rates of fine particles (particulate matter < 2.5 µm in diameter; PM_{2.5}), polycyclic aromatic hydrocarbons (PAHs), aldehydes and ketones. Having applied these measured emission rates to predict indoor concentrations under realistic room conditions, we found that pollutant concentrations resulting from burning mosquito coils could substantially exceed health-based air quality standards or guidelines. Under the same combustion conditions, the tested Malaysian mosquito coils generated more measured pollutants than did the tested Chinese mosquito coils. We also identified a large suite of volatile organic compounds, including carcinogens and suspected carcinogens, in the coil smoke. In a set of experiments conducted in a room, we examined the size distribution of particulate matter contained in the coil smoke and found that the particles were ultrafine and fine. The findings from the present study suggest that exposure to the smoke of mosquito coils similar to the tested ones can pose significant acute and chronic health risks. For example, burning one mosquito coil would release the same amount of PM_{2.5} mass as burning 75–137 cigarettes. The emission of formaldehyde from burning one coil can be as high as that released from burning 51 cigarettes.

Picture: ehp.niehs.nih.gov/members/2003/6177/6177.html. NIEHS

SOLVENTS AND VOLATILE ORGANIC COMPOUNDS

Alkanes, 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: hair sprays, perfumes



www.epa.gov/opplead1/cb/10_tips/

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

All of these products can release organic compounds while they are being used, and, to some degree, when they are stored.

The average levels of several organic compounds in indoor air are 2–5 times higher than in outdoor air. During certain activities, such as paint-stripping, and for several hours immediately afterwards, levels may be 1000 times higher than outdoor levels.

*These notes are taken from the US EPA Website
www.epa.gov/iaq/voc.html*

VOLATILE ORGANIC COMPOUNDS: HEALTH EFFECTS

Acute:

- ❖ Irritation of eyes and respiratory tract
- ❖ General: headache, dizziness, loss of coordination, nausea, visual disorders
- ❖ Allergic reactions, including asthma and rhinitis

Chronic:

- ❖ Damage to liver, kidney, blood system and CNS
- ❖ Some may cause cancer in humans

Volatile organic chemicals (VOC) vary greatly in their health effects: some are highly toxic, whereas some have no known effects on health.

As with other pollutants, the extent and nature of the effects on health will depend on many factors including level of exposure and duration of exposure.

The immediate symptoms experienced after exposure to VOC may include eye, nose and throat irritation; headaches; loss of coordination; nausea; dizziness; and visual disorders. Memory impairment and damage to liver, kidneys and central nervous system (CNS) may also occur. Little is yet known about what effects on health occur from exposure to the levels of organics usually found in homes. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.

Steps to reduce exposure

- Use household products according to manufacturer's directions.
- Make sure to provide plenty of fresh air when using these products.
- Throw away unused or little-used containers safely; buy in quantities that can soon be used.
- Keep out of reach of children and pets.
- Never mix household care products unless directed on the label.

*These notes are taken from the US EPA website
www.epa.gov/iaq/voc.html*

FORMALDEHYDE

Sources: differ according to country

❖ **Developing countries**

- Use of solid fuels indoors
- Mosquito coils

❖ **Industrialized countries**

- Household cleaners and deodorizers
- Glues and resins
- Tobacco smoke
- Carpeting and carpet backing
- Furniture and dyed materials
- Pressed wood products
- Urea formaldehyde insulating foam (UFFI)
- Others

Ref:

• www.epa.gov/iaq/formalde.html

FORMALDEHYDE: HEALTH EFFECTS

- ❖ Irritation of eyes, nose and throat
- ❖ Breathing difficulties
- ❖ Skin rash
- ❖ Severe allergic reactions, including asthma
- ❖ May be a sensitizer
- ❖ May cause cancer

Prevention:

- ❖ Reduce exposure
- ❖ Provide adequate ventilation
- ❖ Maintain moderate temperature and humidity levels

Formaldehyde, a colourless, pungent-smelling gas, can cause watery eyes, burning sensations in the eyes and throat, nausea and difficulty in breathing (wheezing and coughing) in some humans exposed to levels above 0.1 parts per million. High concentrations may trigger attacks in people with asthma. There is evidence that some people can develop a sensitivity to formaldehyde. It has also been shown to cause cancer in animals and may cause cancer in humans.

Reducing exposure to formaldehyde in homes

- Ask about the formaldehyde content of pressed wood products, including building materials and furniture before purchasing them.
- Maintain moderate temperature and humidity levels and provide adequate ventilation.

The rate at which formaldehyde is released is accelerated by heat and may also depend somewhat on the humidity level. Therefore, the use of dehumidifiers and air conditioning to control humidity and to maintain a moderate temperature can help reduce formaldehyde emissions.

*These notes are taken from the US EPA website
www.epa.gov/iaq/formalde.htm*

BIOLOGICAL POLLUTANTS

Biological pollutants are/were living organisms:

Animal dander, dust mites, moulds, infectious agents, pollen

Sources of biological agents:

- ❖ Humidifiers and stagnant water
- ❖ Water-damaged surfaces and materials
- ❖ Water vapour from cooking and showering
- ❖ Air conditioning systems
- ❖ Mattresses, upholstered furniture and carpets

Dust mites, fungi and bacteria require moisture to proliferate. Permeation of rain or groundwater into a building and condensation on cold interior surfaces can promote proliferation of microbes. Water vapour is produced by people and pets, cooking and showering and requires sufficient air exchange to prevent moisture problems. Mattresses, upholstered furniture and carpets are reservoirs for dust mites.

Moulds have been associated with two types of effects: allergic reactions and toxic effects. Toxic effects may be caused by inhalation of mycotoxins.

*These notes are taken from the US EPA website
www.epa.gov/iaq/pubs/bio_1.html*

DUST MITES

- ❖ Feed on human dander
- ❖ Prefer warm, humid environments
- ❖ Sources:
 - bedding, carpets, upholstery, soft toys

Prevention:

- ❖ Encasing mattress and pillows
- ❖ Washing of bedding in hot water
- ❖ Frequent vacuuming / damp mopping
- ❖ Decreasing clutter
- ❖ Removing carpets



CDC

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The effectiveness of prevention measures against dust mite sensitization has been studied in a European multicentre randomized controlled trial. Intervention was a combination of education and mattress encasement. Of 566 preschool-aged children in the study's first-year follow-up (mean age = 3.1 years), the incidence of sensitization to mite allergens was 10 (3%) of 330 in the intervention versus 20 (6.5%) of 306 in the control group.

Likewise, in 213 school age children, 3 (2.56%) of 117 children in the intervention group and 9 (9.38%) of 96 in the control group developed sensitization to dust mite.

Refs:

- Tsitoura. Randomized trial to prevent sensitization to mite allergens in toddlers and preschoolers by allergen reduction and education: one-year results. *Arch Pediatr Adolesc Med*, 2002, 156:1021.
- Arshad. Prevention of sensitization to house dust mite by allergen avoidance in school age children: a randomized controlled study. *Clin Exp Allergy*, 2002, 32:843.

ANIMAL ALLERGENS

- ❖ Cats most allergenic: 6 million people are allergic to cats
- ❖ Birds harbour dust mites
- ❖ Cockroach faeces are linked to asthma morbidity

Prevention:

- ❖ Avoid exposure
 - Allergens persist for many months after removal of source
- ❖ Frequent cleaning of environment and pet(s)
- ❖ Adequate ventilation
- ❖ Dust and moisture control
- ❖ Air filtration

<<READ SLIDE>>

- Dogs are the most common household pet — allergy to dogs is uncommon.
- Cats are most allergenic: 6 million people are allergic to cats.
- Birds harbour dust mites.
- Cockroach faeces are an important cause of asthma morbidity.

Prevention

- Avoid exposure: allergens persist for many months after removal of their source.
- Clean the environment and pet(s) frequently.
- Ensure adequate ventilation.
- Control dust and moisture.
- Use an air filtration system.

Refs:

- McConnell. Cockroach counts and house dust allergen concentrations after professional cockroach control and cleaning, *Ann Allergy Asthma Immunol*, 2003, 91:546.
- Becker. Primary prevention of allergy and asthma is possible. *Clin Rev Allergy Immunol*, 2005, 28:5.

Indoor Air Pollution and Children's Environmental Health

MOULD

- ❖ Occurs in damp indoor spaces
- ❖ Symptoms more common among atopic people

Allergies and nonspecific symptoms are common, but infections are rare

Mold growing on a wooden headboard in a room with high humidity.



EPA

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<<READ SLIDE>>

Ref:Etzel. Indoor mold and children's health. *Environ Health Perspect*, 1999, 107(Suppl)3:463.

Reactive airways disease in children is increasing in many countries around the world. The clinical diagnosis of asthma or reactive airways disease includes a variable airflow and an increased sensitivity in the airways. This condition can develop after an augmented reaction to a specific agent (allergen) and may cause a life-threatening situation within a very short period of exposure. It can also develop after a long-term exposure to irritating agents that cause an inflammation in the airways in the absence of an allergen. (paragraph) Several environmental agents have been shown to be associated with the increased incidence of childhood asthma. They include allergens, cat dander, outdoor as well as indoor air pollution, cooking fumes, and infections. There is, however, increasing evidence that mould growth indoors in damp buildings is an important risk factor. About 30 investigations from various countries around the world have demonstrated a close relationship between living in damp homes or homes with mould growth, and the extent of adverse respiratory symptoms in children. Some studies show a relation between dampness/mould and objective measures of lung function. Apart from airways symptoms, some studies demonstrate the presence of general symptoms that include fatigue and headache and symptoms from the central nervous system. At excessive exposures, an increased risk for haemorrhagic pneumonia and death among infants has been reported. (paragraph) The described effects may have important consequences for children in the early years of life. A child's immune system is developing from birth to adolescence and requires a natural, physiological stimulation with antigens as well as inflammatory agents. Any disturbances of this normal maturing process will increase the risk for abnormal reactions to inhaled antigens and inflammagenic agents in the environment. (paragraph) The knowledge about health risks due to mould exposure is not widespread and health authorities in some countries may not be aware of the serious reactions mould exposure can provoke in some children. Individual physicians may have difficulty handling the patients because of the lack of recognition of the relationship between the often complex symptoms and the indoor environment.

MOULD-RELATED DISEASES

- ❖ Airway and conjunctival irritation
- ❖ Headache
- ❖ Difficulty in concentrating
- ❖ Hypersensitivity reactions: asthma, rhinitis
- ❖ Infections due to immune effects
- ❖ Acute exposure associated with pulmonary haemorrhage in infants

Mould-related diseases include:

- ❖ irritation of the airways and conjunctiva:
 - eye irritation, cough and sore throat
- ❖ headache
- ❖ difficulty in concentrating
- ❖ hypersensitivity reactions:
 - asthma
 - allergic rhinitis
- ❖ Infections:
 - thrush (candidiasis)
 - systemic infections (immunosuppression)
- ❖ acute toxicity:
 - linked to pulmonary haemorrhage in infants.

Hypersensitivity to moulds is immediate (type 1) and includes: acute asthma, allergic rhinitis and urticaria (hives) (which is uncommon).

Colonization associated with chronic asthma is rare and serious (allergic bronchopulmonary mycosis and allergic mycotic sinusitis).

Deep fungal infections are uncommon: serious, life-threatening diseases are not caused by common household moulds. The major exception is aspergillosis. Moulds usually infect devitalized tissue or an immunocompromised host.

Ref: Etzel. Indoor mold and children's health. *Environ Health Perspect*, 1999, 107(Suppl 3):463.

CHEMICAL AGENTS ELABORATED BY MOULDS

Mycotoxins are associated with human disease and cause acute and chronic effects

- ❖ Mycotoxins
 - Tricothecenes
 - Ochratoxins and citrinin
 - Aflatoxins

- ❖ Volatile organic compounds (irritating)
- ❖ Glucans (cell wall components)

Mycotoxins are associated with human disease.

Tricothecenes inhibit protein synthesis and cause many acute effects, including pulmonary haemorrhage.

Ochratoxins and citrinin cause nephropathy and immunosuppression.

Aflatoxins are hepatotoxins and are carcinogenic.

(See module on Mycotoxins)

**INDOOR AIR QUALITY:
BUILT ENVIRONMENT**

- ❖ Housing materials:
 - Asbestos, wood preservative, paints and others

- ❖ Ventilation
- ❖ Heating
- ❖ Air conditioning

The “built environment” refers to houses, offices and other manmade structures in which people live, work and play.

The materials used in their construction may release toxicants into the air. Lack of ventilation (and hygiene) increases the risk of exposure, which may be further enhanced by heating and faulty air conditioning.

SICK BUILDING SYNDROME

What is this syndrome?

- ❖ Discomfort not related to specific illness
- ❖ Effects appear to be linked to time spent inside the building
- ❖ Cause of symptoms is unknown
- ❖ Most complaints relieved soon after leaving the building

Building related illness: symptoms of identified illness attributed to airborne contaminants in the building

When energy prices soared in the 1970s there was a movement to make buildings “tight” to preserve heat in winter and air conditioning in summer. The unexpected consequence, in some buildings, was an increase of indoor pollution due to inadequate ventilation. Pollutants from off-gassing from building materials together with other indoor pollutants were trapped in some structures and built up to levels that caused symptoms in sensitive individuals. "Sick building syndrome" is the name that was given to this phenomenon.

Ref:

Indoor Air Facts N° 4: Sick Building Syndrome.
www.epa.gov/iaq/pubs/sbs.html

SICK BUILDING SYNDROME

Causes:

- ❖ Inadequate building design
- ❖ Occupant activities
- ❖ Remodelled buildings operating in a manner inconsistent with their original design
- ❖ Inadequate ventilation
- ❖ Inadequate maintenance
- ❖ Chemical and biological contaminants

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SICK BUILDING SYNDROME

Symptoms:

- ❖ Headache
- ❖ Irritation of eyes, nose or throat
- ❖ Dry cough
- ❖ Dry or itchy skin
- ❖ Difficulty in concentrating
- ❖ Fatigue
- ❖ Sensitivity to odours

Solutions:

- ❖ Remove source of pollutant
- ❖ Increase ventilation
- ❖ Air cleaning: filters
- ❖ Education and communication

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RADON

- ❖ Radon is a radioactive gas released from soil and rocks
- ❖ It is the second leading cause of lung cancer
- ❖ Geology of the area can predict levels in soil and water
- ❖ Radon concentrations indoors depend on construction site and building materials
- ❖ Highest levels occur in basements and on the ground floor

Radon is a radioactive gas that comes from the soil. Exposure to radon gas is the second-leading cause of lung cancer (after smoking) in the United States. About 14 000 people die each year from radon-related lung cancer.

Radon is produced from the natural breakdown of thorium and uranium found in most rocks and soils. As it further breaks down, radon emits atomic particles. These particles are in the air we breathe and can be deposited in the lungs. The energy associated with these particles can alter DNA, leading to an increased risk of lung cancer.

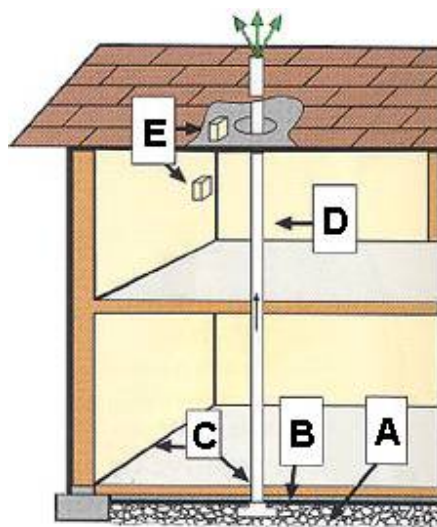
Radon does not usually present a health risk outdoors because it is diluted in the open air. Radon can, however, build up to dangerous levels inside a house. Radon can enter a new house through cracks or pores in concrete flooring and walls or through openings in the foundations, floor-wall joints or loose pipes. The differences in air pressure between the inside of a building and the soil around it also play an important role in radon entry. If the air pressure of a house is greater than that of the soil beneath it, radon will remain outside. However, if the air pressure of a house is lower than that of the surrounding soil (which is usually the case), the house will act as a vacuum, sucking radon gas inside. Because radon comes from the soil, a knowledge of the geology of an area can help to predict the potential for elevated indoor radon levels.

*These notes are taken from the US EPA website
www.epa.gov/radon/index.html*

RADON MITIGATION SYSTEM

- A – Gas-permeable layer
- B - Plastic sheeting
- C - Sealing and caulking
- D - Vent pipe
- E - Junction box

It is recommended that homes be tested for radon on the lowest lived-in level – basement or ground floor



www.epa.gov/iaq/radon/construc.html

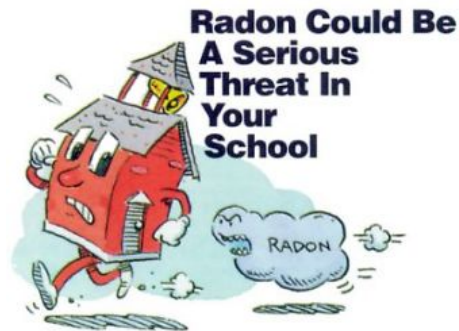
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- A. Gas-permeable layer.** This layer is placed beneath the slab or flooring system to allow the soil gas to move freely underneath the house. In many cases, the material used is a 4-inch layer of clean gravel.
- B. Plastic sheeting.** Plastic sheeting is placed on top of the gas-permeable layer and under the slab to help prevent the soil gas from entering the home. In crawlspaces, the sheeting is placed over the crawlspace floor.
- C. Sealing and caulking.** All openings in the concrete foundation floor are sealed to reduce entry of soil gas into the home.
- D. Vent pipe.** A 3- or 4-inch gas-tight or PVC pipe (commonly used for plumbing) runs from the gas permeable layer through the house to the roof to safely vent radon and other soil gases above the house.
- E. Junction box.** An electrical junction box is installed in case an electric venting fan is needed later.

Testing is not necessary above the second story.

*These notes are taken from the US EPA website
www.epa.gov/iaq/radon/construc.html.*

RADON IN SCHOOLS



www.epa.gov/radon/pubs/schoolrn.html

Schools should also be tested for radon:

- ❖ Levels above 4 pCi/L call for action to reduce exposure

A USA survey of radon levels in schools estimated that nearly one in five schools has at least one schoolroom with a short-term radon level above 4 pCi/L (picoCuries per litre) – the level at which EPA recommends that schools take action to reduce the level. EPA estimates that more than 70 000 schoolrooms in use today have high short-term radon levels.

Ref:

- www.epa.gov/radon/pubs/schoolrn.html

ASBESTOS

Sources:

- ❖ Building construction materials used for insulation and as a fire-retardant: asbestos cement, floor tiles, water pipes and others
- ❖ Levels increase if asbestos-containing materials are damaged

Health effects:

- ❖ NO acute toxicity
- ❖ Asbestosis results from occupational exposure
- ❖ Main risk for children: long-term exposure may cause cancer
 - Lung cancer
 - Malignant mesothelioma

Asbestos is a fibrous mineral product and is classified into six types: amosite, chrysotile, crocidolite, tremolite, actinolite and anthophyllite. It is very resistant and almost indestructible and has been used widely in manufactured products and building materials. Inhalation of microscopic fibres is the major route of exposure. Fibres are liberated from deterioration, destruction or renovation of asbestos-containing materials. Asbestos produces no acute toxicity. Workers exposed to asbestos in industry may develop asbestosis. The main risk for children is the long-term exposure that may lead to cancers, such as lung cancer and malignant mesothelioma.

*These notes are taken from the US EPA websites
www.epa.gov/iaq/asbestos.html and
www.epa.gov/asbestos/ashome.html*

Ref:

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

OCCUPATION-RELATED INDOOR CONTAMINANTS – INCLUDING AIR

Parents “take home” exposures related to work:

- ❖ Contaminated clothing, shoes and skin
- ❖ Contaminated exhaled breath
- ❖ Bring home empty containers of pesticide and others

Children are directly exposed when

- ❖ Visiting parents' workplaces
- ❖ Participating in work

Prevention

- ❖ Change work clothes and shower before hugging or playing with children

Clothing contaminated with pesticides and other chemicals can be an important source of exposure for children and a source of indoor air contamination. Exposures of family members to pesticides have occurred from contact with contaminated skin, clothing or shoes, contamination of the family car, and during visits to the workplace. Parents should avoid hugging children or playing with them after coming home from work until they have showered and changed their clothes.

CHILDREN WORKING INDOORS

Child labour and adolescent work: exposure to pesticides, solvents, cleaning agents and other chemicals indoors

- ❖ Young children employed illegally
- ❖ Unregulated temporary work
- ❖ School-based vocational training
- ❖ Family businesses
- ❖ Cottage industries
- ❖ Indoor smoke from solid fuels (e.g. food for sale)
- ❖ Volunteer service projects

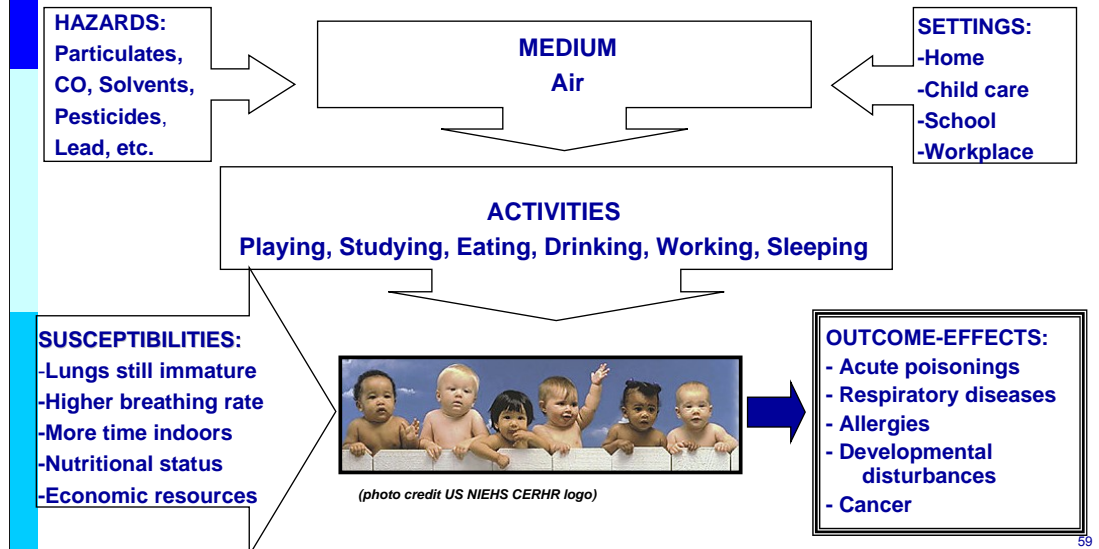
Children and adolescents are likely to work without proper training and protective equipment, leading to their being exposed to dangerous products and pesticides, mainly when they are being employed illegally or doing unregulated work.

Solvents and cleaning agents are important sources of exposure of employed adolescents. Their workplaces include fast-food restaurants, automotive services, retail stores and others. One of the most common types of exposure is to cleaning products containing ammonia or other airway irritants. Other common sources of exposures include paints, glues and solvents, caustic agents, hydrocarbons and bleach. Chemical burns have also been reported.

Another group of adolescents or younger children who may suffer potentially hazardous exposures to pesticides are the children of farm-workers working in the fields beside their parents.

Indoor Air Pollution and Children's Environmental Health

SUMMARY SLIDE



Different hazards are presented by different settings and various children's activities. The effects of exposure are influenced by individual susceptibility which depends upon age, developmental stage, nutrition and social support. Pollutants in the indoor environment are potentially more hazardous to children than adults because their lungs are still growing and maturing; younger children breathe more air than older children or adults; and they spend more time indoors. All of these susceptibilities are modified by nutritional status and economic resources.

APPROACHES TO REDUCE INDOOR AIR POLLUTION

1. Eliminate or control the sources of pollution
 - ❖ Regular maintenance of cooking, heating and cooling systems
 - ❖ Choose non-volatile, non-toxic building materials
2. Ventilation – building design
 - ❖ Dilute and remove pollutants through ventilation with outdoor air
3. Air cleaning – NOT air fresheners
 - ❖ Air filters and ionizers may remove some airborne particles
 - ❖ Gas adsorbing material is used to remove gaseous contaminants

It is always better to prevent rather than treat illness. To avoid problems due to indoor air quality, the first approach is source reduction and elimination, and the second, proper ventilation and maintenance of gas, oil and solid fuel cooking, heating and cooling systems. Air cleaning is the least effective, and most expensive. Air fresheners, which contain untested potentially harmful VOCs, should not be used to cover up stale air or unpleasant smells.

Ref:

• www.epa.gov/iaq/pubs/ozonegen.html

For more information on indoor air pollution, you can obtain a guide (*Indoor pollution: An introduction for health professionals*) recently published by the US EPA at:

www.epa.gov/iedweb00/pubs/hpguide.html

OZONE GENERATORS AS AIR CLEANERS

- ❖ Ozone can be harmful to health
 - Chest pain, coughing, throat irritation
- ❖ Ozone is ineffective in controlling indoor air pollution below health standards levels
 - NIOSH / OSHA recommends an upper limit of 0.10 ppm
- ❖ High concentrations are used to decontaminate unoccupied spaces from chemical and biological contaminants or odours

Ozone generators have become popular in some industrialized countries. Ozone is a molecule composed of three atoms of oxygen. The third oxygen atom can detach from the ozone molecule, and re-attach to molecules of other substances, thereby altering their chemical composition. Scientific evidence shows that, at concentrations that do not exceed public health standards, ozone has little potential to remove indoor air contaminants: there is no approval for its use in occupied spaces.

When inhaled, ozone can damage the lungs. Relatively small amounts can cause chest pain, coughing, shortness of breath and throat irritation. Ozone may also exacerbate chronic respiratory diseases such as asthma and compromise the ability of the body to fight respiratory infections. People vary widely in their susceptibility to ozone.

<<READ SLIDE>>

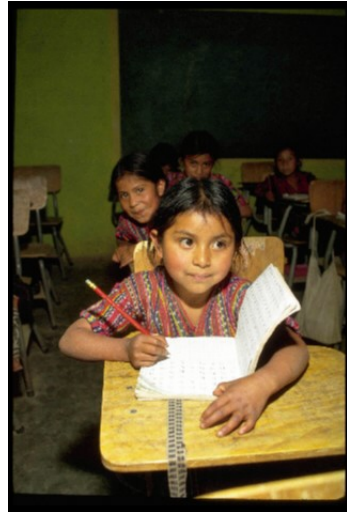
*These notes are taken from the US EPA website
www.epa.gov/iaq/pubs/ozonegen.html*

PREVENTION OF EXPOSURE

- ❖ Education of:
 - Children
 - Family
 - Health care providers

- ❖ Environment policy-making
 - Community actions

- ❖ Research



WHO

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A multi-level approach to prevention of indoor air-related illness is required. Education, policy and research all have roles to play.

<<READ SLIDE>>

<<NOTE TO USER: Insert appropriate suggestions for tackling the specific indoor air problems in your area.>>

Picture: WHO, C. Gaggero. School child, Americas

Indoor Air Pollution and Children's Environmental Health

CRITICAL ROLES OF HEALTH & ENVIRONMENT PROFESSIONALS



WHO

- ❖ **Diagnose and treat**
- ❖ **Do research and publish**
 - Detect sentinel cases
 - Inspire 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 ensure children's health through a clean indoor environment.

- At the patient level it is important to include indoor air as an environmental etiology or trigger of respiratory disease and in the preventive advice. Are the signs and symptoms possibly linked to air pollutant exposure? Are there any potential indoor sources of exposure?
- Health care providers should be alert and detect the "sentinel" cases of indoor air pollutant exposure. Their detection and study will be essential for developing, proposing and supporting family and community-based interventions. Publication of cases and research studies allows the communication of knowledge and experience that will benefit other communities and countries.
- It is important to inform and educate patients, families, colleagues and students didactically, on the possibility of exposure to indoor air pollutants and its potential impact in children. Also on how to avoid exposure and provide clean air.
- Finally, we must all become vigorous advocates for the protection of children's environments and prevention of exposure to indoor air pollutants. It is important to promote the measures that are crucial for eliminating or mitigating sources of exposure in children (and pregnant women!).
- Professionals with understanding of both health and the environment are powerful role models. Their choices and opinions with respect to air pollutants and other environmental factors will be noticed by patients and communities.

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