TRAINING FOR THE HEALTH SECTOR

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CHILDREN AND RADIATION

Children's Health and the Environment

WHO Training Package for the Health Sector

World Health Organization

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World Health Organization

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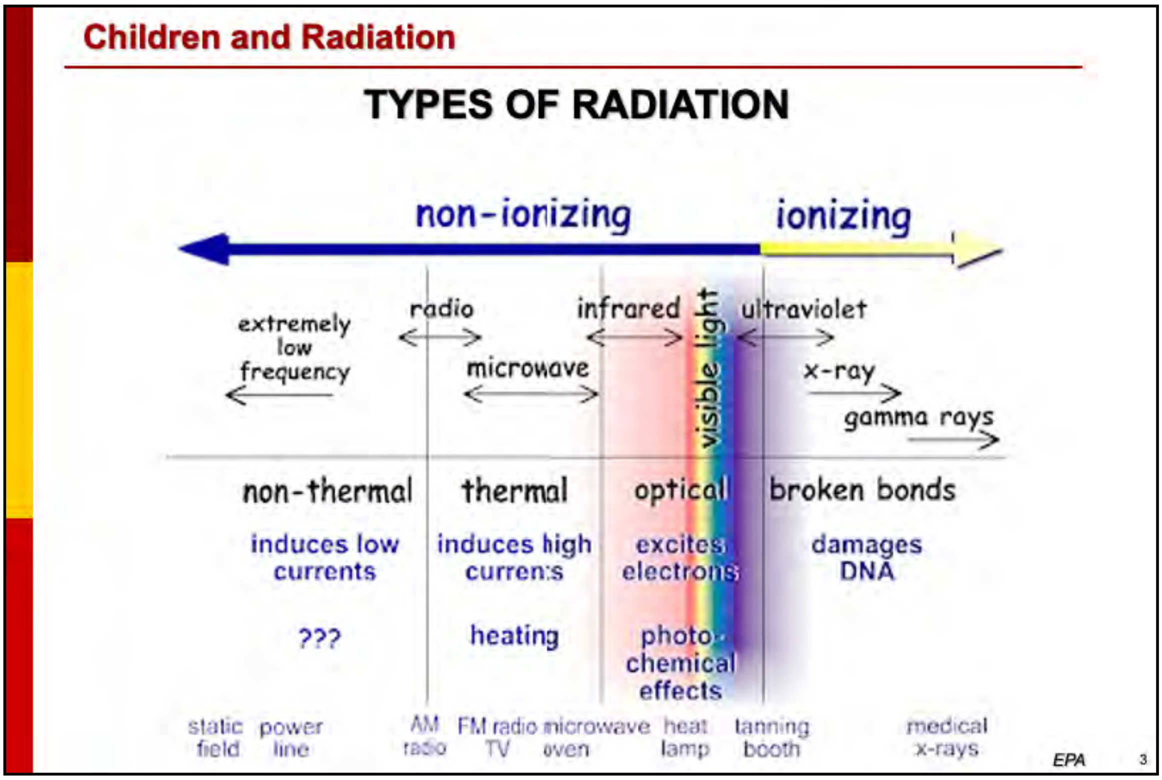
<<NOTE TO USER: This is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local situation in the region.>>

LEARNING OBJECTIVES
AFTER THIS PRESENTATION INDIVIDUALS WILL:

- Understand basic principles of radiation physics
- Identify the sources of radiation exposure
- Understand the range of potential health effects
- Understand the basic principles of radiation protection and their application in paediatric healthcare
- Be able to describe preventive strategies



Radiation is energy that is radiated or transmitted in the form of waves or particles.

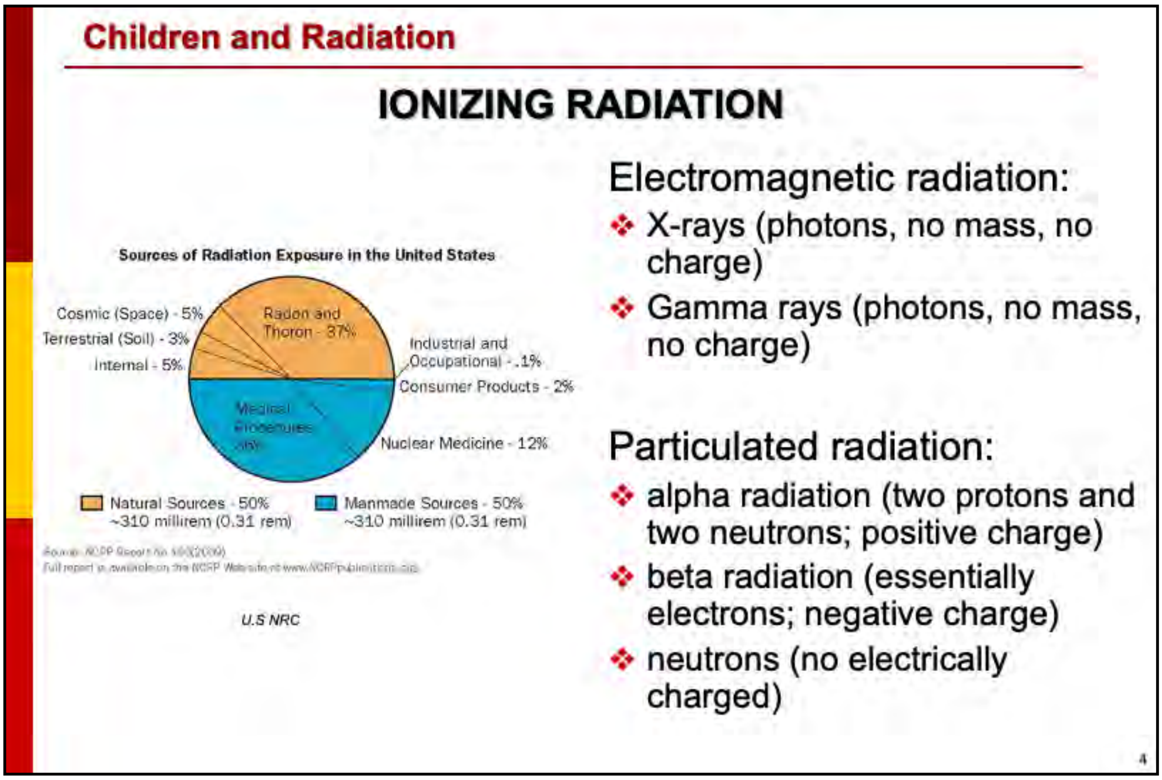
According to their frequency and energy, electromagnetic waves can be classified as either "ionizing radiation" (IR) or "non-ionizing radiation" (NIR).

Ionizing radiation (IR) has enough energy to remove electrons from atoms, thus creating ions. Its properties can be used for the production of energy, diagnosis and treatment of diseases, agricultural and manufacturing processes.

Non-ionizing radiation (NIR) is a general term for that part of the electromagnetic spectrum which has photon energies too weak to break atomic bonds. It includes ultraviolet (UV) radiation, visible light, infrared radiation, and electric and magnetic fields with diverse applications in communication, industry and medicine.

Image:

•*US Environmental Protection Agency, EPA. Ionizing and non-ionizing radiation. Available at: www.epa.gov/radiation/understand/index.html – accessed December 2009*



Ionizing radiation is radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized.

There are two basic types of ionizing radiation: electromagnetic and particulated. Electromagnetic ionizing radiation such as X-rays and gamma rays has discrete packets of energy called "photons" that have neither mass nor electric charge. While X-rays come from the electronic part of the atom, gamma radiation originates in the nucleus. Electromagnetic ionizing radiation is used in pediatric healthcare for both imaging and cancer treatment.

Particulate radiation involves tiny fast-moving particles that have both energy and mass. Particulate radiation is primarily produced by disintegration of an unstable atom and the energy is carried by sub-atomic particles such as electrons, protons and neutrons. Beta and alpha radiation are examples of particulate radiation.

<<READ SLIDE>>

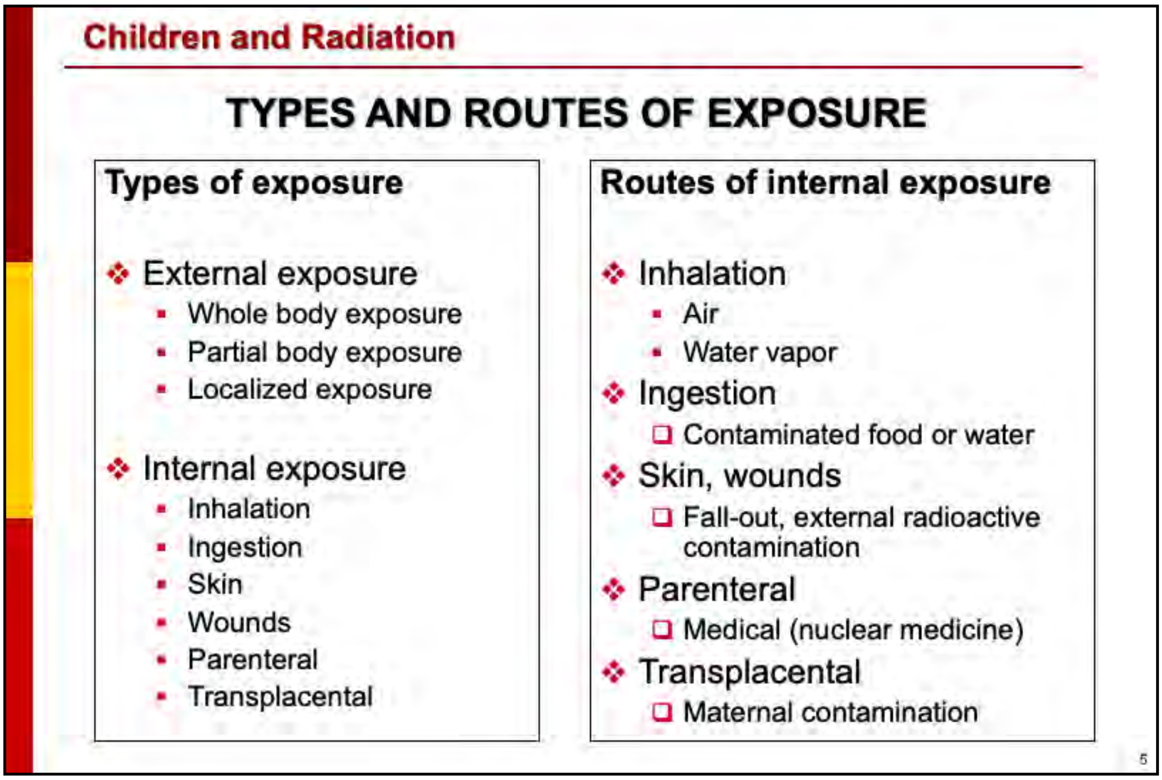
Ionizing radiation is a known carcinogen to which children are particularly vulnerable. Relevant exposures include pre- and postnatal irradiation for medical reasons, radon in the home, and accidental radiation releases. In some cases, children may receive higher doses than adults because of higher intake and accumulation. Furthermore, sensitivity to radiation is highest early in life. Although the mechanism of greater susceptibility is not well understood, it is likely to be linked to greater cell division in growing and developing tissues. In addition, a longer expected lifetime, with a resultant increased chance of repeated exposure and accumulated damage, also leads to higher cancer risk for children. Fetuses might be particularly sensitive to ionizing radiation, since their tissue cells are not only undergoing high rates of division, but are also differentiating into mature functional cells.

Reference:

•*Ionizing radiation, Part 1: X- and gamma-radiation, and neutrons.* Lyon, International Agency for Research on Cancer, 2000 (IARC Monographs on the Evaluation of the Carcinogenic Risk to Humans, Volume 75).

Image:

•*U.S NRC (U.S. Nuclear Regularoty Commission) www.nrc.gov/reading-rm/basic-ref/glossary/exposure.html – Reprinted with permission of the National Council on Radiation Protection and Measurements, NCRPonline.org*



Children can be exposed to radiation by a variety of routes.

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Children and Radiation

UNITS OF MEASUREMENT

Absorbed dose

- **Gray (Gy): 1 Gy = 100 rads**

Equivalent dose

- **Absorbed dose X "radiation weighting factor" (Wr)**
- **Sievert (Sv): 1 Sv = 100 rems**

Effective dose

- **Equivalent dose X "tissue weighting factor" (Wt)**
- **Sievert (Sv) 1 Sv = 100 rems**

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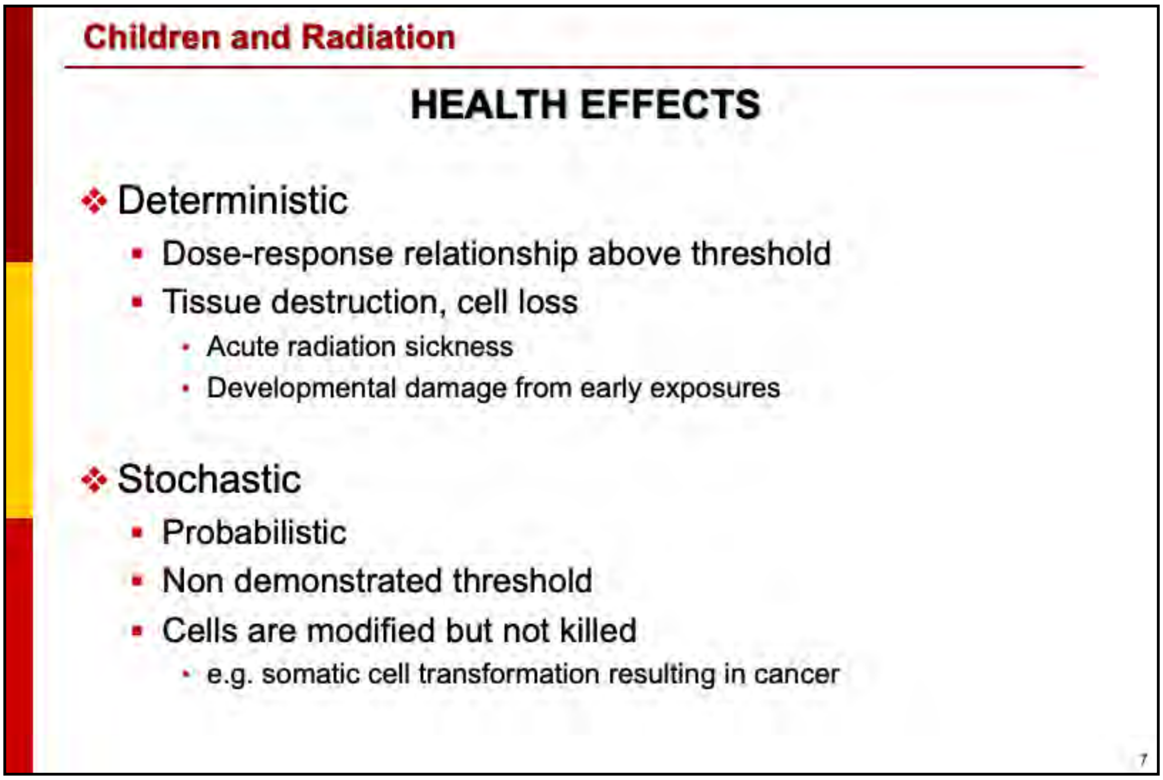
The absorbed dose is a measure of the amount of energy actually absorbed in a material, and is used for any type of radiation and any material. Gray (Gy) is the unit of measurement for absorbed dose in the International System of Units (SI). In the old system of units 1 Gy = 100 rads.

One gray is equal to one joule of energy deposited in one kg of a material. The unit gray can be used for any type of radiation, but it does not describe the biological effects of the different radiations Absorbed dose is often expressed in terms of fractions of a gray (e.g. centi-gray: cGy; milligray: mGy).

The equivalent dose is the product of the absorbed dose and a "radiation weighting factor" depending on the quality of the particular type of radiation (e.g. 1 for X-rays, gamma rays and beta particles, 20 for alpha radiation, between 1-10 for neutrons). This weighting factor relates the absorbed dose in human tissue to the effective biological damage of the radiation.

The effective dose is the product of the equivalent dose and a " tissue weigthing factor" which reflects different sensitivities to radiation of different organs and tissues in the human body. It is, in simple terms, the sum of the equivalent doses received by all tissues or organs, further weighted by the “tissue weighting factors”. Effective dose allows to express radiation detriment to the whole body as a summation of doses to different organs. The SI unit for the equivalent and effective dose is the sievert (Sv), where 1 Sv = 1 J/kg. In the old system of units 1 Sv = 100 rems.



The biological effects of ionizing radiation are the combined result of *direct* absorption of energy at molecular level and the *indirect* oxidative damage produced by the reactive oxygen species ("free radicals") produced through a process called water radiolysis. (i.e. direct and indirect effects). Direct and indirect effects may lead to recognizable damage particularly when they affect molecules of biological importance. The DNA molecule is the principal target for the biological effects of ionizing radiation, including cell killing and mutations leading to non-lethal cell transformation.

Cellular damage from ionizing radiation depends on the type of radiation, the energy deposition rate, and the distribution through the tissue. Biological effects also depend on the radiosensitivity of the tissue exposed. Two kinds of effects of radiation on tissues are observed.

-*Deterministic effects* (or "tissue reactions") occur when a large number of cells have been damaged and as a result of that, the tissue structure or function is affected. These effects occur at doses above a certain threshold, with the frequency and the severity of effects increasing sharply above this threshold. To the extent that the organism is able to compensate for the loss of cells, the harm may be temporary. Examples of deterministic effects are nausea, diarrhoea, skin damage and sterility.

-*Stochastic effects* occur when cells are not killed, but are modified. Some of the changes may persist in daughter cells. Examples of stochastic effects are cancer in the individuals who have been exposed to radiation if the transformation occurred in a somatic cell, and hereditary diseases in descendants of individuals exposed, if the transformation occurred in a germ cell (i.e.