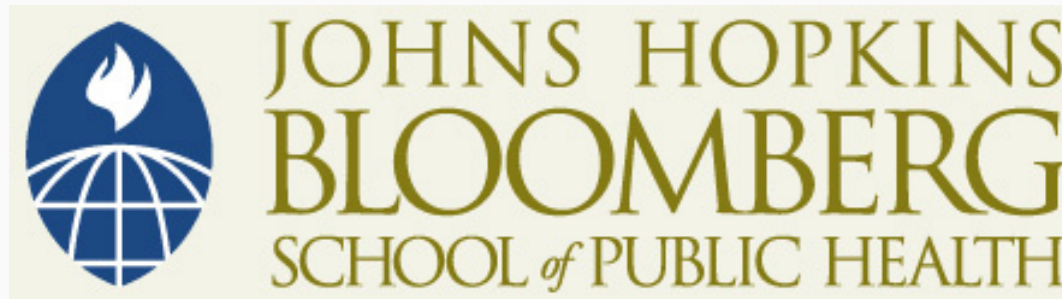


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Radiation Terror 101

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Part 2

General Radiation Principles, Part II

Exposure Paradigm

- **Agent** = ionizing radiation
 - Alpha and beta particles, X rays and gamma rays
- **Source** = radioactive atoms
 - Emit the ionizing radiation
- **Exposure**
 - External exposure = directly from the radiation
 - Internal exposure = from radiation emitted from radioactive atoms in the body

Exposure Paradigm

- **Vector** = air, water, soil, food
 - Carries the radioactive atoms into the body
- **Routes of entry** = inhalation, ingestion, absorption

Exposure Paradigm

- **Vector** = air, water, soil, food
 - Carries the radioactive atoms into the body
- **Routes of entry** = inhalation, ingestion, absorption
 - How radioactive atoms enter the body

Ionizing Radiation Exposure (United States)

Ionizing Radiation Exposure (U.S.)

Average Annual Effective Dose Equivalent (U.S.)		Annual Dose (All Sources)	
Natural Source	Dose Equivalent (mrem)*	Source Contribution to Dose	
Radon	200	Radon	55%
In the body	39	In the body	11%
Terrestrial	28	Terrestrial	8%
Cosmic	27	Cosmic	8%
		Medical	15%
		Products	3%
		Other	1%

** mrem is a unit of radiation dose*

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Ionizing Radiation Effects: Deterministic and Random

■ **Deterministic**

- Severity is a function of dose
- Threshold exists
- Examples: skin reddening, mental and growth retardation, cataract formation

■ **Random**

- Risk is a function of dose
- No threshold
- Example: cancer

Ionizing Radiation Effects: Acute

■ **Acute—deterministic effects**

- Prodomal syndrome: 100+ rem
- Hematopoietic syndrome: 100s of rem
- Gastrointestinal syndrome: 1,000s of rem
- Central nervous system syndrome: 10,000s of rem
- Near 100% fatality: 600 rem

Ionizing Radiation Effects: Delayed

- **Delayed—stochastic and deterministic effects**
 - Random: cancer, genetic changes
 - Burns, cataract formation: 100 rem threshold
 - Growth and mental retardation: 10 rem threshold

Cancer Risks

ICRP Fatal Cancer Risk: Baseline (Non-Radiogenic) Fatal Cancer Risk = 25%			
Dose		Risk	
1 mrem	.01 mSv*	5×10^{-7}	.00005%
10 mrem	.1 mSv	5×10^{-6}	.0005%
100 mrem	1 mSv	5×10^{-5}	.005%
1 rem	10 mSv	5×10^{-4}	.05%
10 rem	.1 Sv	5×10^{-3}	.5%
100 rem	1 Sv	5×10^{-2}	5%
1000 rem	10 Sv	5×10^{-1}	50%

*1 mSv=100 mrem

Radiation Safety and Protection

- Exposure = intensity x time
- The “Big 3:”
 - **Time**
 - **Distance**
 - **Shielding**

Radiation Safety and Protection

- Time
 - Exp_{∞} time
- Distance
 - $\text{Exp}_{\infty} 1/d^2$
- Shielding
 - $\text{Exp}_{\infty} 1/\text{attenuation}$
 - Particulate: defined range to stop all radiation
 - Electromagnetic: exponential attenuation