IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Managing the Medical Response to a Nuclear or Radiological Emergency

IAEA-KINS Workshop on the Emergency Preparedness and Response to Nuclear and Radiological Emergencies

19 - 23 June 2023, Daejeon, Republic of Korea

Introduction

- Requirement 12: *“The government shall ensure that arrangements are in place for the provision of appropriate medical screening and triage, medical treatment and longer term medical actions for those people who could be affected in a nuclear or radiological emergency.”*

Nuclear or Radiological Emergency.

Definition

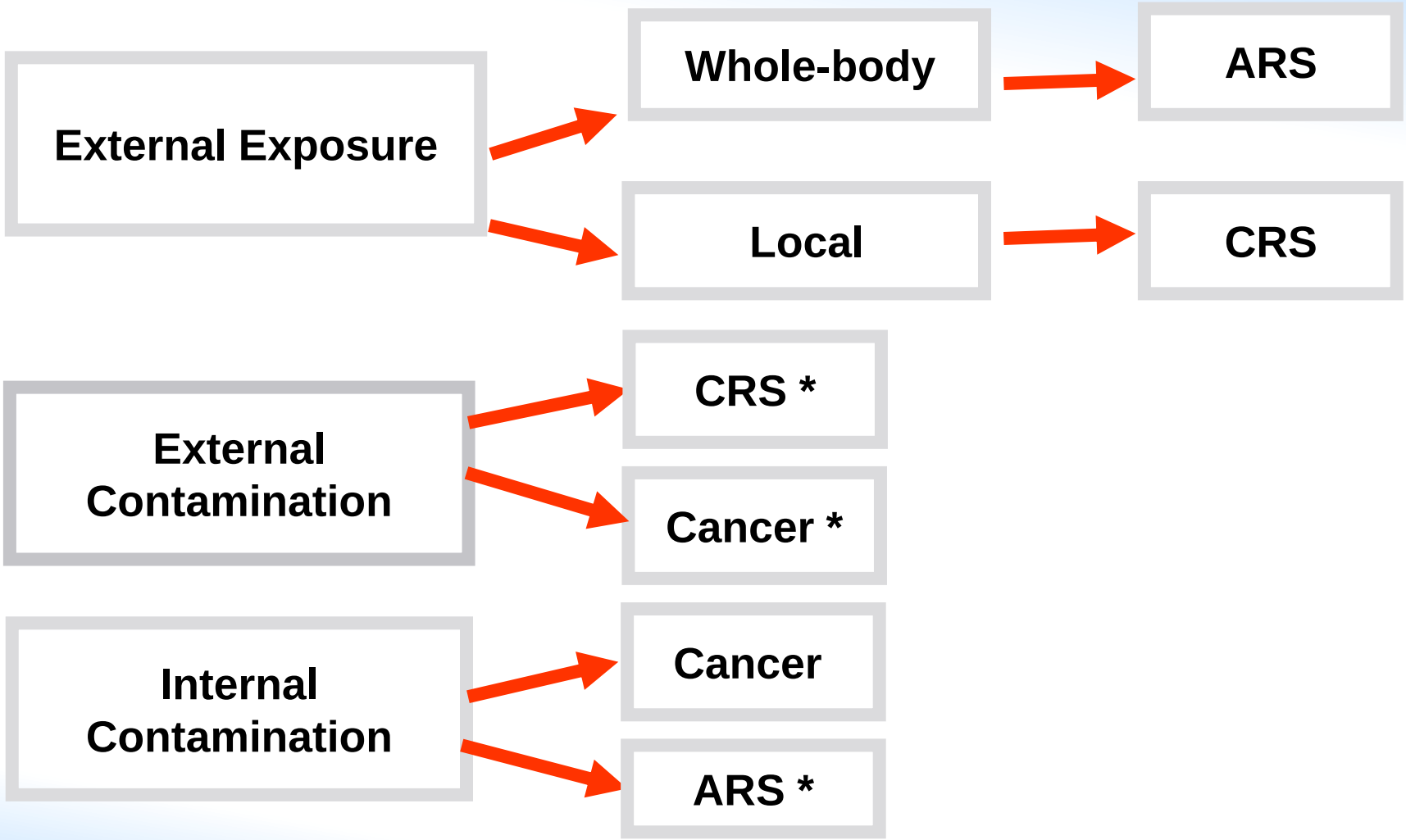
“An emergency in which there is, or is perceived to be, a hazard due to:

(a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; [or]

(b) Radiation exposure.”

[IAEA Safety Glossary, 2018]

Nuclear or Radiological Emergency.
Possible Exposure Pathways and Consequences



* Depends on the dose

Scope of the Problem

- Nuclear or radiological emergencies are uncommon, *but* can lead to significant medical, psychosocial, environmental and economical burdens!
  - Examples:
    - The NUCLEAR accident at Chernobyl NPP
    - The RADIOLOGICAL accident in Goiânia

Scope of the Problem (cont.)

- The overall response to a nuclear or radiological emergency is based on the same fundamentals as the response to any other emergency

but….

- Ionizing radiation cannot be perceived by human senses

- Ionizing radiation can easily be detected by instruments (detectors)

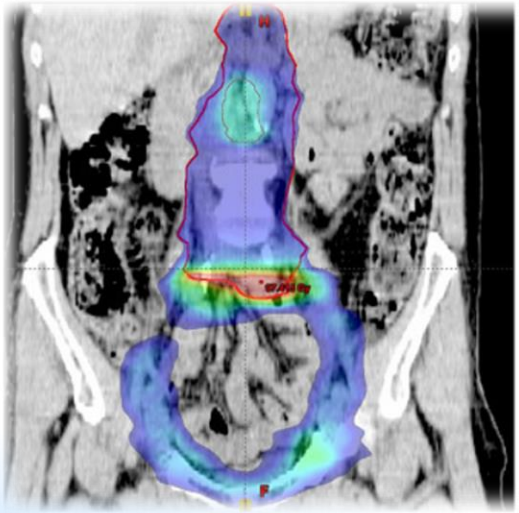
- **The medical community in general is <u>not</u> able to timely recognize radiation-induced manifestations**

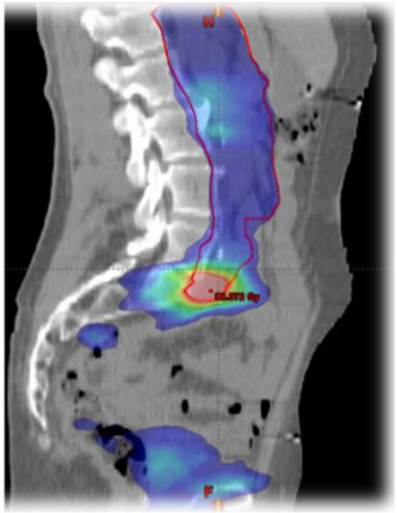
Scope of the Problem (cont.)

- Planning and preparedness are essential for an adequate medical response
  - e.g. radioactive contamination
- Myths and misinformation **DO** exist concerning “the danger” and the biological effects of ionizing radiation
- These types of emergencies are **not** generally included in the curriculum of medical schools

Image courtesy IAEA

Scope of the Problem (cont.)





Images courtesy IAEA

Scope of the Problem (cont.)

Image courtesy IAEA

Significant Radiological Emergencies in the Past Decades

Year	Place	Radionuclide, circumstances	Number of exposed persons	Number of deaths
2000	Egypt	^{192}Ir	7	2
2000	Thailand	^{60}Co	> 10	3
2001	Panama	radiotherapy	28	6
2001	Poland	radiotherapy	5	0
2001	Georgia	^{90}Sr	3	1
2002	Bolivia	^{192}Ir, transport	59	0
2005	Chile	^{192}Ir	4	0
2005	Venezuela	^{137}Cs	3	0
2006	Senegal & Ivory Coast	^{192}Ir	4	0
2006	Venezuela	^{60}Co, transport	3	0
2006	Belgium	^{60}Co	1	0
2006	UK	^{210}Po	1	1
2009	Ecuador	^{192}Ir	1	0
2010	Venezuela	^{192}Ir	3	0
2010	India	^{60}Co	7 (?)	1
2012	Peru	^{192}Ir	3	0
2014	Peru	^{192}Ir	3	0
∑			**145**	**14**

Significant Nuclear Emergencies of the Past Decades

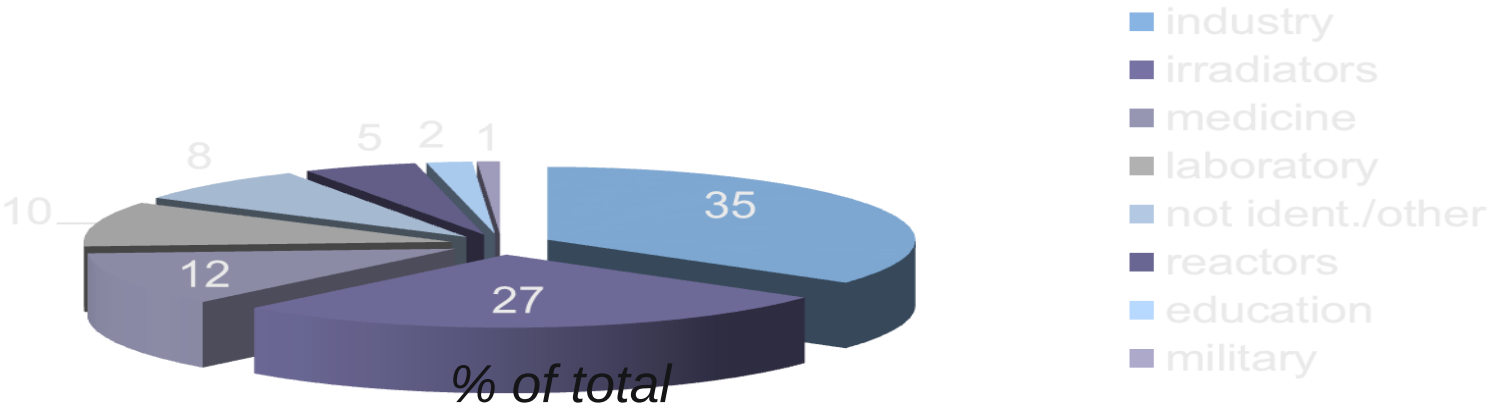
- Three Mile Island, USA – 1979
- Chernobyl, USSR – 1986
- Tokaimura, Japan – 1999
- Fukushima, Japan – 2011

Where do Nuclear or Radiological Emergencies Occur?

- Irradiation facilities
- Nuclear reactors (power and research)
- Isotope production facilities
- Industrial radiography
- Defectoscopy (sealed sources)
- Defectoscopy (X ray devices)
- X ray and radiotherapy devices (medicine, research)
- Transport of radioactive materials
- Anywhere (e.g. unsealed radiation source)
- Others

“Major” Worldwide Nuclear or Radiological Emergencies (since 1945)

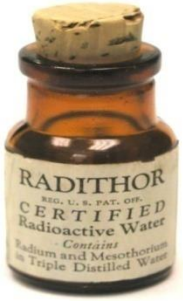
- Number: ~500
- Fatalities:
  - radiation related: ~130
  - not related to radiation: ~10

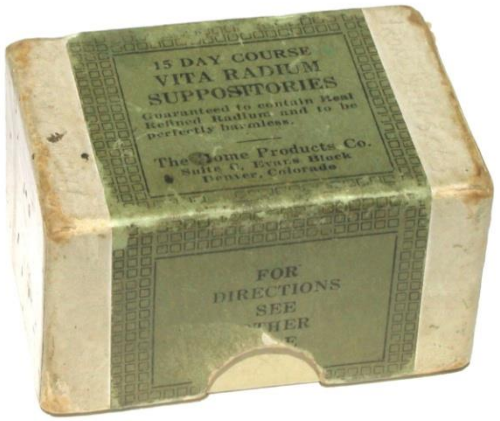


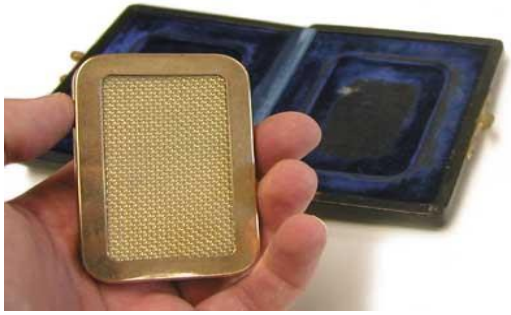
Biological Effects

- Soon after the discovery of X rays and of radioactivity, harmful radiation effects were observed
- Biological effects of ionizing radiation are mainly classified as ***deterministic or stochastic***
- The most important target for radiation – ***DNA***

Futile Use of Ionizing Radiation



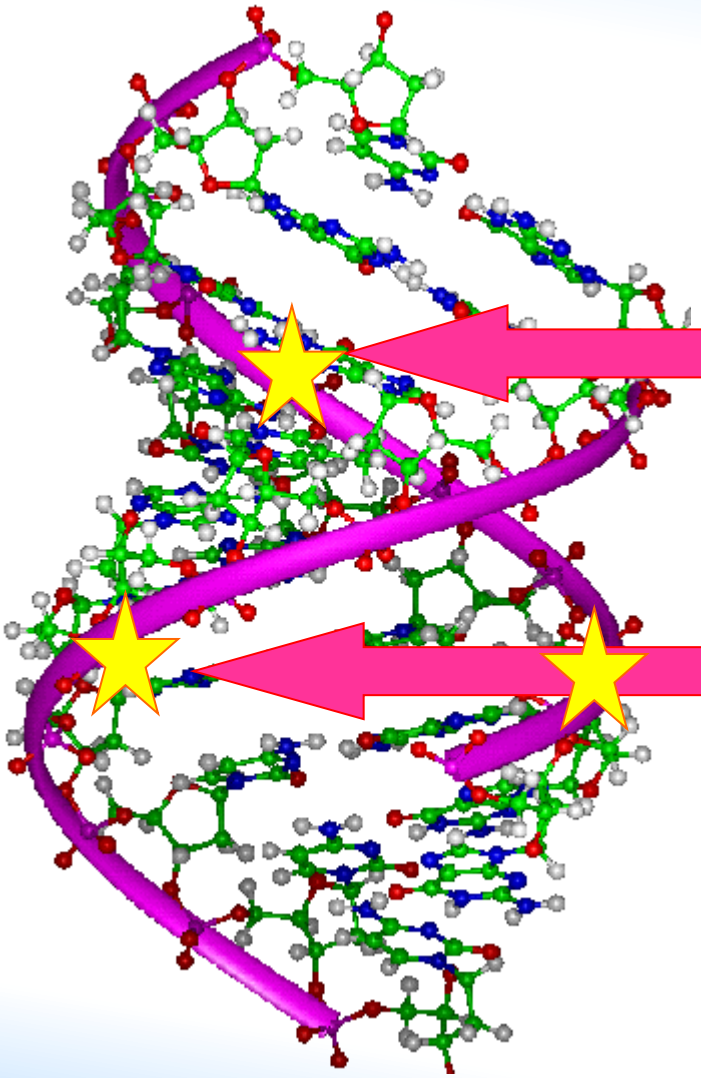




Images from Oak Ridge Associated Universities

Can you share any other examples?

Strand Breaks



Single – SSB

Double – DSB

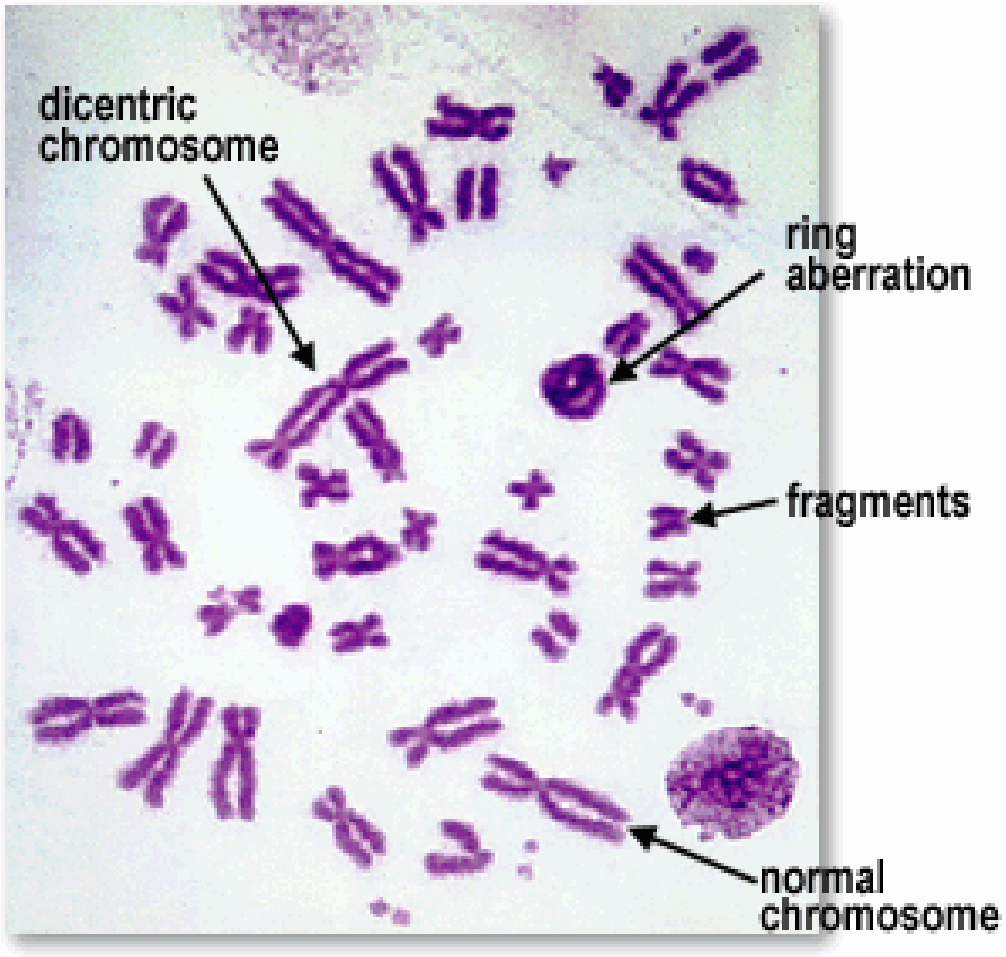
Examples of Cellular Radiosensitivity

Relative radiosensitivity	Cell
Very high	BM stem cells, spermatogonia, intestinal crypts cells
High	Precursor haematopoietic cells
Mild	Endothelial cells, fibroblasts
Relatively low	Liver and kidneys epithelial cells, salivary glands cells
Low	Neuronal cells, red cells, muscle cells

Lymphocytes

- Lymphocytes are the most sensitive cells in circulating blood and very sensitive to ionizing radiation
- Lymphocytes serve as ideal biological dosimeters because they:
  - are very sensitive to radiation
  - are readily available in routine blood samples
  - circulate throughout the body
  - are easily cultured and induced to divide in vitro
  - respond consistently by expressing dose dependent chromosomal DNA damage

Dicentric Chromosome and Other Anomalies



Courtesy and permission of Dr. Gordon Livingston, Oak Ridge Institute of Science

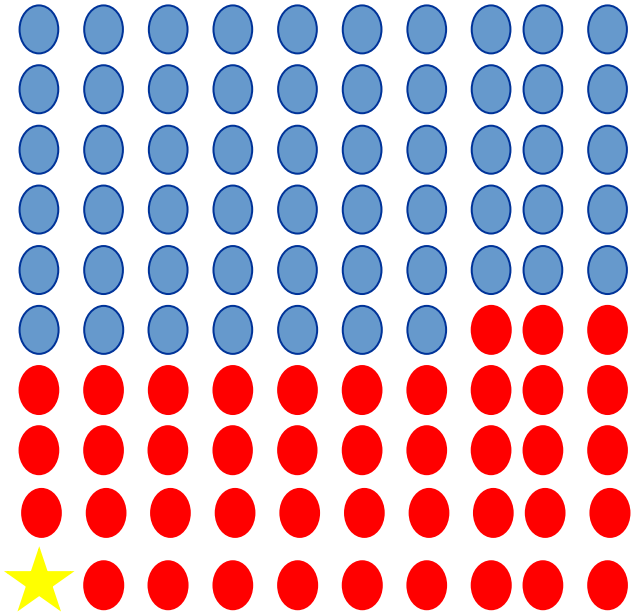
Possible Biological Consequences of Radiation Exposure Depend on:

- Dose
- RBE of the radiation
- Type of exposure: external or internal
- “Uniformity” of external exposure
- Dose rate
- Distribution of radionuclides through human body in case of internal exposure
- Cell, tissue and organ radiosensitivity

Risk for Radiation Induced Cancer

- One additional case (★) during whole life for 100 persons, each exposed to 100 mSv (in addition to natural background)
- 42 other cases produced by different causes

BEIR VII Report 2006
– Low LET Radiation



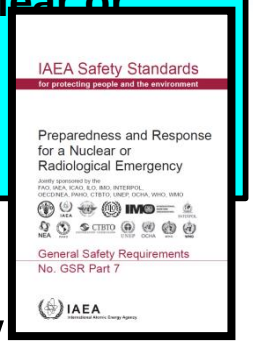
UNSCEAR Report (2000)

- Whole life risk increase for solid cancers (all ages):
  - 1 Sv whole-body acute dose: 11%
  - Protracted dose: 5.5%

- Whole life risk increase for leukaemia (all ages):
  - 1 Sv whole-body acute dose: 1%
  - Non-linear risk:
    - A dose 10 times lower, would lower the risk 20 times

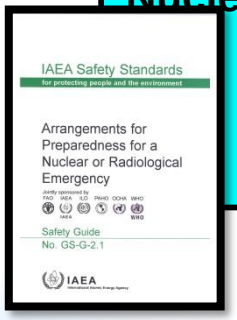
Criteria for Use in Planning Response to Nuclear and Radiological Emergencies

Preparedness and Response for a Nuclear or Radiological Emergency
GSR Part 7
(2015)

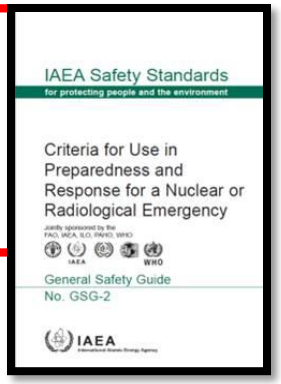


ICRP-103
(2007)

Safety Guide on Arrangements for Preparedness for a Nuclear or Radiological Emergency
GS-G-2.1
(2007)



General Safety Guide on Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency
GSG-2
(2011)



TECDOC-1432, Development of an Extended Framework for Emergency Response Criteria, Interim Report (2005)

Image courtesy IAEA

System of Protective and Other Response Actions

Types of possible consequences	Basis for implementation of protective actions and other response actions	
	Projected dose	**Received dose**
Severe deterministic health effects	Precautionary urgent protective actions, even under adverse conditions, to prevent severe deterministic effects	Other response actions for treatment and management of severe deterministic effects

Generic Criteria to Avoid or Minimize Deterministic Effects

Acute external, local and contact exposure

Organ or tissue	Projected RBE weighted absorbed dose (<10 hr)
Red marrow	1 Gy
Foetus	0.1 Gy
Soft tissue	25 Gy at 0.5 cm depth to 100 cm^2 of tissue
Skin derma	10 Gy at 0.4 mm depth to 100 cm^2 of tissue

Generic Criteria to Avoid or Minimize Deterministic Effects (cont.)

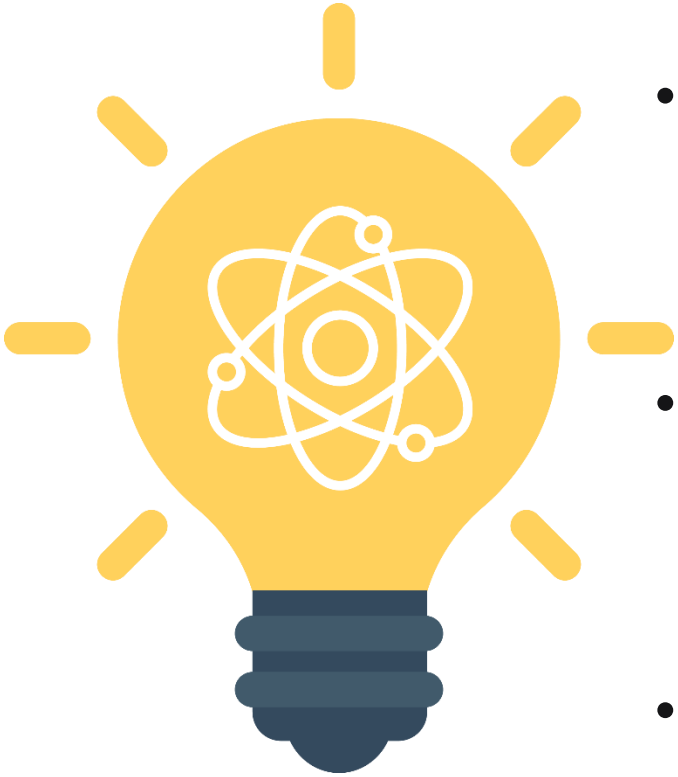
Internal exposure

Organ or tissue	Projected 30-day committed RBE weighted absorbed dose
Red marrow	0.2 Gy [radionuclides with Z >= 90] 2 Gy [radionuclides with Z <= 89]
Thyroid	2 Gy [thyroid seeking radionuclide]
Lung	30 Gy
Colon	20 Gy
Foetus	0.1 Gy

System of Protective and Other Response Actions

Types of possible consequences	Basis for implementation of protective actions and other response actions	
	Projected dose	**Received dose**
Increase in the risk of stochastic health effects	Urgent and early protective actions to reduce the risk of stochastic effects as far as reasonably possible	Other response actions for early detection and effective management of stochastic effects

Key Points



- Planning and preparedness are essential for an adequate medical response to radiation emergencies
- Myths and misinformation DO exist concerning “the danger” and the biological effects of ionizing radiation
- Risk of one additional case during whole life for 100 persons, each exposed to 100 mSv (in addition to natural background)

Where to Get More Information

- IAEA GSR Part 7 (2015)
- IAEA GSG-2 (2011)
- IAEA EPR-Medical (2005)

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Thank you!

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