Risk in Radiological Protection

Consultancy meeting to prepare input for a draft Safety Report on ‘The Implications of the UNSCEAR 2012 Report on Sources, Effects and Risks of Ionizing Radiation for the regulation of safety and the communication of risk’

2019 March
Vienna

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an individual, professional view

from an ICRP perspective
Radiological protection is PROSPECTIVE

It guides decision making for FUTURE ACTION

therefore,

Primary interest is prospective risk estimation

Retrospective observations are of interest to RP insofar as they inform prospective estimation
“Well Founded” & “Conditional” Predictions for Risk Estimation

- (a) Observed health effect in an individual
- (b) Observed increased frequency of occurrence of health effects in a population

Observations

- Diagnosis
- Epidemiology

Risk

Prospective

- Hypotheses deemed proven
- Hypotheses currently not deemed proven

Risk estimation

- (c) Well-founded predictions of health effects in individuals or increased risk of health effects in populations
- (d) Conditional predictions of increased risk of health effects in populations

Adapted from UNSCEAR 2012 Annex A
Primary Aim of ICRP Recommendations

“Contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure”
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“Contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure”
‘Risk’ in Radiological Protection

Role of Risk:

- To balance positive and negative consequences
  - e.g. to assess “tolerable” and “acceptable” doses for particular circumstances
- To compare consequences of disparate actions / circumstances involving exposure to ionising radiation

Negative consequences include, but are not limited to, deleterious effects of exposure to ionising radiation
Manage and control exposures so that:

• **Harmful tissue reactions (deterministic effects)** are prevented

• **Risks of cancer or heritable effects (stochastic effects)** are reduced to the extent reasonably achievable

ICRP Publication 103, para 29
Cancer & Heritable Effects  
(Stochastic Effects)

Harmful Tissue Reactions  
(Deterministic Effects)

Additional Dose $\rightarrow$ Probability $\rightarrow$ Additional Dose

Severity $\rightarrow$
The nature of risk is different for tissue reaction (deterministic) and cancer & heritable (stochastic) effects.
**Mechanism**
Injury to populations of cells

**Model for Protection**
Severity of effect increases with dose above a threshold

**Protection Aim**
Prevent harmful reactions

→ *Dose limitation aided by optimisation* (to keep doses below threshold)

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**Harmful Tissue Reactions**
(Deterministic Effects)
e.g. necrosis, cataract induction, circulatory disease
Harmful Tissue Reactions
(Schematic Approximation of Understanding)

Risk = Probability x Consequence

- Probability of effect
- Additional Dose
- Severity of effect
- Additional Dose
Harmful Tissue Reactions
(Simplified Model for Protection)

Risk = Probability of effect \rightarrow Additional Dose \rightarrow x \rightarrow Severity of effect

Risk = \text{Additional Dose} \times \text{Severity of effect}
Focus is on the likelihood of effect, in particular on the threshold, since the aim is to PREVENT harmful tissue reactions.

In principle, the aim is zero risk due to harmful tissue reactions. However:

- the threshold value is based on ~1% incidence
- there is uncertainty about individual response
- there may be inherent randomness
Cancer & Heritable Effects
(Stochastic Effects)

Mechanism
Mutation of individual cells

Model for Protection
Probability of effect increases with dose without threshold

Protection Aim
Reduce risk to the extent reasonably achievable

→ Optimise protection (to keep doses As Low As Reasonably Achievable) constrained by limits
Cancer & Heritable Effects
(Schematic Approximation of Understanding)

Risk = 

Additional Dose → Probability of effect → Probability

Additional Dose → Severity of effect → Consequence

Risk = Probability of effect × Severity of effect

ICRP
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
Cancer & Heritable Effects
(Simplified Model for Protection)

Risk = Probability of effect → Additional Dose → Probability

Consequence

Additional Dose → Severity of effect →
“Risk” (detriment) focuses on the slope of the lower part of this curve i.e. “risk” per unit dose at low doses.

This relies on epidemiologically derived frequencies of effect, and semi-subjective assessment based on radiobiological findings.

An uncertain possibility of a threshold = an uncertain increase in the DDREF value (ICRP Publication 99).
“… bearing in mind the uncertainties associated with risk projection to low doses, [effective dose] may be considered as an approximate indicator of possible risk, with the additional consideration of variation in risk with age, sex and population group. Use of [effective dose] in this way is not a substitute for risk analysis using best estimates of organ/tissue doses, appropriate information on the relative effectiveness of different radiation types, and age-, sex- and population-specific risk factors, with consideration of uncertainties.”

This refers to inference based on conditional predictions of risk
RP is interested in **prospective risk estimation**

**Risk is viewed differently for different effects**

- Deterministic effects: aim for **zero risk** (not always possible e.g. in medical exposures)
- Stochastic effects: **manage risk** (much more complex)

**Risks of most interest** are in the low-dose and low-dose rate region, where there is significant uncertainty

**RP needs risk estimation models**

- Based on the best understanding from all domains of science
- Adequate to drive practical protection
In addition to prospective risk estimation, RP relies on:

- Ethical judgements related to risk vis-à-vis tolerability and reasonableness
- Practicality of recommendations

**RP looks beyond radiological risk**

- This should not be isolated from other risks and benefits
- People accept (or not) circumstances/activities, not risks

**Advances in scientific understanding** demand more complex models and detailed assessments than are necessary for radiological protection
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