ICRP Recommendations
Evolution or Revolution?

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Main Commission

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ICRP Recommendations

1. Reasons for new Recommendations
2. Summary of health risks
3. Summary of changes to dosimetry
4. The ‘New’ System of Protection
Need for ‘New’ Recommendations

- 30 different numerical restrictions established in different ways
- Over-elaborate terminology
- Need to include protection of non-human species
- Consolidate and clarify
Aims of the Revision

• To take account of new biological and physical information and of trends in the setting of radiation safety standards

• To improve and streamline the presentation of the recommendations

• To maintain as much stability as is consistent with the new scientific information
Primary Aim of the Recommendations

To contribute to an appropriate level of protection for people and the environment without unduly limiting the desirable human actions that may be associated with radiation exposure.
Major Features (1)

• Updated radiation and tissue weighting factors

• Updated radiation detriment based on the latest available science

• Fundamental principles remain justification, optimisation, and the application of dose limits

• Clarification on how they apply to sources delivering exposure and to individuals receiving exposure
• Evolution from a process-based protection approach (practices and interventions) to a situation-based approach (planned, existing and emergency)

• The principles of justification and optimisation of protection apply to all controllable exposure situations

• Individual dose limits are maintained for all regulated sources in planned exposure situations
• Optimisation is reinforced, applicable in a similar way to all exposure situations, with restrictions on individual doses and risks:
  – Dose/risk constraints for planned exposure situations
  – reference levels for emergency and existing exposure situations

• An approach for radiological protection of the environment is included
Health Effects

- Deterministic effects (harmful tissue reactions) – due to cell killing/malfunction characterised by a dose threshold

- Stochastic effects – cancer and heritable effects owing to mutation of cells assumed for radiological protection purposes not to have a dose threshold
Bases for ICRP cancer risk estimates

- Largely based on new cancer incidence data for the Japanese A-bomb survivors
  - not available at the time of ICRP Publication 60; mortality data used there
  - more accurate diagnoses in incidence data

- A-bomb data cover population of all ages and both genders, with a wide range of doses & long follow-up
Cancer risks at low doses

- Issue considered in depth in ICRP Publication 99
  - weight of evidence suggests that, at doses below about 100 mSv, it is plausible to assume that cancer risk will rise in direct proportion to an increase in the equivalent dose in the relevant organs and tissues

- For radiological protection purposes, ICRP judge it prudent to adopt this linear non-threshold model

- However, uncertainties in the assessment of risks at low doses are recognised
Cancer Detriment

Detriment-adjusted cancer risk (% per Sv)

<table>
<thead>
<tr>
<th></th>
<th>Whole population</th>
<th>Working population</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICRP 2007</td>
<td>5.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Publication 60</td>
<td>6.0</td>
<td>4.8</td>
</tr>
</tbody>
</table>

- Estimate of fatal cancer risk for a population of all ages is now around 4% per Sv, compared with 5% per Sv in Publication 60

- However, in view of uncertainties in risk estimates, ICRP recommends that 5% per Sv continue to be used for radiological protection purposes
Hereditary effects

• Not demonstrated convincingly in human populations
  – eg offspring of A-bomb survivors but compelling evidence from studies on experimental animals

• New methodology adopted to estimate hereditary risks (UNSCEAR, 2001)
  – takes account of advances in understanding of human genetic diseases & mutagenic processes
  – incorporates new methods to estimate risks of multifactorial diseases
  – focuses on risk in first two generations
  – calculations indicate that the risk in the first ten generations is similar to that in the first two
## Total detriment

<table>
<thead>
<tr>
<th>Detriment components</th>
<th>Whole population</th>
<th>Working population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>(Publ 60)</td>
</tr>
<tr>
<td>Cancer</td>
<td>5.5</td>
<td>(6.0)</td>
</tr>
<tr>
<td>Hereditary</td>
<td>0.2</td>
<td>(1.3)</td>
</tr>
<tr>
<td>Total</td>
<td>5.7</td>
<td>(7.3)</td>
</tr>
</tbody>
</table>

(Note: The manner in which detriment is calculated has changed slightly, reflecting the greater focus now on cancer incidence rather than mortality)
Non-cancer diseases

• Raised risks of heart, digestive and respiratory diseases seen among Japanese A-bomb survivors
  – data consistent with both no dose threshold in risk and with a threshold of 0.5 Gy

• Heart disease also increased among patients given radiotherapy to areas around the heart
  – doses were generally several Gy or more

• ICRP and UNSCEAR highlight difficulty in knowing whether there are raised risks below 0.5 Gy
  – these diseases not included in detriment estimates
  – will be considered further by an ICRP Task Group
Protection quantities: what’s new?

- Changes to radiation and tissue weighting factors, $w_R$ and $w_T$
- Adoption of defined phantoms
- Sex-averaging in calculation of effective dose
- Clarity on intended use of ICRP quantities
## Radiation weighting factors

*ICRP, 1991*

<table>
<thead>
<tr>
<th>Radiation</th>
<th>$w_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photons, electrons and muons of all energies</td>
<td>1</td>
</tr>
<tr>
<td>Neutrons</td>
<td></td>
</tr>
<tr>
<td>$&lt; 10$ keV</td>
<td>5</td>
</tr>
<tr>
<td>$10$ keV $&lt; 100$ keV</td>
<td>10</td>
</tr>
<tr>
<td>$100$ keV $&lt; 2$ MeV</td>
<td>20</td>
</tr>
<tr>
<td>$2$ MeV $&lt; 20$ MeV</td>
<td>10</td>
</tr>
<tr>
<td>$&gt; 20$ MeV</td>
<td>5</td>
</tr>
<tr>
<td>Protons $&gt; 2$ MeV (except recoil protons)</td>
<td>2</td>
</tr>
<tr>
<td>Alpha particles and heavy ions</td>
<td>20</td>
</tr>
</tbody>
</table>
Radiation weighting, $w_R$ for neutrons

Function modified from Publication 92
Tissue weighting factors \( w_T \)

Represent the contribution of individual organs and tissues to overall detriment from cancer and hereditary effects

New values in new recommendations based on cancer incidence rather than fatality, weighted for lethality, life-impairment, risk of hereditary effects

Rounded values applying to both sexes and all ages
## Tissue weighting factors

<table>
<thead>
<tr>
<th>Type</th>
<th>Factor</th>
<th>Tissues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>0.01</td>
<td>bone surface, skin</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>bladder, breast, liver, oesophagus, thyroid, remainder</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>bone marrow, colon, lung, stomach</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>gonads</td>
</tr>
<tr>
<td>New</td>
<td>0.01</td>
<td>bone surface, skin, brain, salivary glands</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td>bladder, liver, oesophagus, thyroid</td>
</tr>
<tr>
<td></td>
<td>0.08</td>
<td>gonads</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>bone marrow, colon, lung, stomach, breast, remainder</td>
</tr>
</tbody>
</table>
# Tissue weighting factors
## - remainder

Remainder $w_T (0.12)$ apportioned equally to 13 tissues,

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenals</td>
<td>Oral Mucosa</td>
</tr>
<tr>
<td>Extrathoracic region</td>
<td>Pancreas</td>
</tr>
<tr>
<td>Gall bladder</td>
<td>Prostate (male)</td>
</tr>
<tr>
<td>Heart Wall</td>
<td>Small intestine wall</td>
</tr>
<tr>
<td>Kidney</td>
<td>Spleen</td>
</tr>
<tr>
<td>Lymph nodes</td>
<td>Thymus</td>
</tr>
<tr>
<td>Muscle</td>
<td>Uterus/Cervix (female)</td>
</tr>
</tbody>
</table>
Sex averaging in calculation of Effective Dose

\[ E = \frac{H_T}{W_T} \]

- Male Phantom
- Female Phantom
- Tissue doses
- Intake or exposure
Use of effective dose

A protection device

Allows summation of doses from different radionuclides and external dose

Use for regulatory purposes for comparison with dose limits / constraints

Relates to stochastic effects only
Use of effective dose

Not individual specific

- reference biokinetic and dosimetric models, and defined $w_R$ and $w_T$ values, are used to calculate reference dose coefficients for protection purposes
**Misuse of Equivalent and Effective dose**

Not for assessments of doses and risks to specific individuals

Not for epidemiological studies

Not for assessment of tissue reactions

**Instead use:**

Absorbed doses in organs / tissues
RBE data
Specific risk estimates
Future Publications

- Phantoms for adults
- Radionuclide decay data
- Occupational intakes reports, replacing Publication 30, giving dose coefficients and bioassay data
- Dose conversion coefficients for external radiation
- Phantoms for children, pregnant woman / fetus
Background to New System of Protection

ICRP 60

Practices - add exposures and risks
Interventions - reduce exposures and risks

Two Systems ! ?

Process based system
ICRP 60

Common features:

Justification: any decision that alters the radiation exposure should do more good than harm

Optimisation: the likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should be kept as low as reasonably achievable, taking into account economic and societal factors.
New Recommendations

Core system:

Justification for increase or decrease in exposures

Optimisation to provide the best protection under the prevailing circumstances, maximising the margin of benefit over harm.

Applies to all exposure situations
New Recommendations

Key Points

- System of Protection applies to all sources and exposures, including natural

- Application of the system will depend upon the characteristics of the exposure situation

- There will be a level of dose (or risk) which should not be exceeded. This will depend on the situation - a constraint/reference level
New Recommendations

Existing Situations
- Natural sources
- Past practices

Core System
- Justification
- Optimisation with restriction

Planned Situations
- Practices
- Medical Exposures

Emergency Situations
- Preparedness and response
Dose Constraints and Reference Levels

Values above which one plans not to go, and below which one strives to reduce all actual doses

Planned exposure: Dose constraint
Diagnostic reference level

Emergency exposure: Reference level

Existing exposure: Reference level
New Recommendations

Optimisation

- Prospective Dose
  - reject options
  - acceptable options

Constraint/ reference level

Constraints and reference levels are an integral part of optimisation
## Framework for Dose Constraints/Reference levels

<table>
<thead>
<tr>
<th>Bands of Projected Dose</th>
<th>Characteristics and Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1 mSv</td>
<td>Societal benefit (not individual). No information, training or individual monitoring. Assessment of doses for compliance.</td>
</tr>
<tr>
<td>1 - 20 mSv</td>
<td>Individual direct or indirect benefit. Information, training and either individual monitoring or assessment.</td>
</tr>
<tr>
<td>20 - 100 mSv</td>
<td>Exceptional situations. Benefit on a case-by-case basis. Information, training and individual monitoring of workers, assessment of public doses.</td>
</tr>
</tbody>
</table>
## Levels of Protection

<table>
<thead>
<tr>
<th>Dose Limits</th>
<th>Dose Constraints and Reference Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protect individuals from</strong> public and occupational <strong>exposure</strong>... from all regulated sources, in planned exposure</td>
<td>from a source, in all exposure situations</td>
</tr>
</tbody>
</table>

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**INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION**
Planned Situation

Include:

• Normal Operation of and Potential Exposures from Practices
  – No change to dose limits
  – ‘Critical Group’ changed to ‘Representative Person’
• Medical Exposures

A planned situation is one where you can choose in advance whether to accept the beneficial situation and its consequent exposures

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
Implementation of Practices

1. Proposal for a Practice
2. Justification for increased exposure
3. Select constraints
4. Optimisation
5. Select optimum protection option
6. Implement option

Plan Protection in Advance

Retrospective comparison

Operation
Medical Exposure

• Patients
  - diagnostic, interventional and therapeutic purposes
  diagnostic reference levels for medical imaging

• Comforters and carers
  - knowingly and willingly exposed
    5 mSv per episode

• Volunteers in biomedical research
  - dose constraints
    value linked to benefit to society
Medical Exposure

Radiation Protection in Medicine  
C3 Building Block Document (Pub 105)  
Lead M. Rosenstein

Topical advice on various medical topics
Emergency Situations

Include:

Emergency Preparedness

Emergency Response
The Use of Reference Level

• The reference level is a planning tool to define the level of dose which it is planned not to exceed and below which protection should be optimised.

• The reference level represents the level of dose where protection is almost always warranted (justification).

• Once an emergency situation has occurred (emergency response) the reference level can be used as a benchmark for assessing the effectiveness of protection strategies.

The chosen value of the reference level will depend upon the circumstances of the exposure situation.
Application of Reference Level in Emergencies

Prospective Preparedness

- Select Option B
- Option A
- Option C

Retrospective Response

- Actual dose distribution for which planned protection strategy has been implemented
- Optimise
- Focus particular attention on this part of the dose distribution (region)

Reference Level

Actual dose distribution after further optimised protection strategies, if any, have been applied
Optimisation below reference levels

- Consider each option of a protection measure on its own merits.

- Consider simultaneously doses that would be incurred via all exposure pathways, some subject to protective actions and some not.

- If the total residual dose to some individuals is so high to be unacceptable, the feasibility of additional protective measures influencing the major contributions to the total residual dose should be considered.
Forthcoming C4 Publications

Application of the Commission’s Recommendations

– For the Protection of People in Emergency Exposure Situations.
– To the Protection of Individuals Living in Long Term Contaminated Territories after a Nuclear Accident or Radiation Emergency.
Existing Exposure Situations

Include:

Natural Sources
Residues from past practices

Characteristics

• De facto large distributions of individual exposures
• Sometimes difficult to control (most often mainly controllable through pathways)
• In many cases, the level of exposure is driven by individual behaviour
• Often affecting habitation
ICRP and Radon

• Policy broadly similar to Publication 65 (1993)

• Upper values for reference levels

  - 600 Bq m\(^{-3}\) domestic

  - 1500 Bq m\(^{-3}\) workplace

  (1000 Bq m\(^{-3}\) entry point to occupational exposure)
Scope

• ICRP recommendations are not limited in scope

• Scope of control measures must be limited for legal and practical reasons

• Scope of control $\approx$ scope of regulation

• Basis of recommendations on scope are: justification and optimisation with constrained individual doses
Exclusion and Exemption

- Two main concepts associated with the scope of radiological protection

**Exclusion**
- Deliberate omission of exposure situations

**Exemption**
- Waiving requirements where they are not warranted
- “Clearance” is a special case of exemption

Publication 104 considers the application of these concepts in the three exposure situations
Protection of the Environment

- NOT driven by concerns of existing radiation hazards

- Fills a conceptual gap
  - Science to show if the environment is adequately protected
  - and methods to improve protection if required

- Further guidance is being provided

- No proposal for dose limits for environmental protection
New Recommendations

Optimisation

Prospective Dose

\{ reject options \}

Constraint/reference level

\{ acceptable options \}

Constraints/reference levels are an integral part of optimisation
Conclusions

ICRP 60 - process based system
- practices and intervention

ICRP 103 - Situation based system
- Process is the same
- All conceivable exposure situations
- Updating of biological effects and tissue and radiation weighting factors

Main change in Emergency Planning and Response

Planned exposure situations include practices - no change to this system

New Recommendations published in December 2007
Answer

EVOLUTION!