Emergencies, Ethics, and Evolution

Nordic Nuclear and Radiation Risk Estimates – Advances and Uncertainties

Joint NKS-R & NKS-B Seminar

Stockholm, 15th January 2019

Dr Claire Cousins
Chair, ICRP
27 July 1928: International X-Ray and Radium Protection Committee is formed

1950: Renamed International Commission on Radiological Protection (ICRP)
ICRP Mission

Advance for the public benefit the science of radiological protection, in particular by providing recommendations and guidance on all aspects of protection against ionising radiation.
Structure ICRP

Main Commission

Scientific Secretariat

Committee 1
Effects

Committee 2
Doses

Committee 3
Medicine

Committee 4
Application

TASK GROUPS
Main Commission Stockholm 2018

Absent: Carl-Magnus Larsson
266 members from 38 countries

as of 2018 September 12, including liaison organization primary contacts
Independent • Non-governmental • Non-profit

Charitable Incorporated Organisation
(UK Registered Charity #1166304)

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Receiving regular voluntary support from organisations with an
interest in radiological protection
Thanks to our Supporters
24 Active Task Groups

TG36 Radiopharmaceutical Doses
TG64 Cancer Risk from Alpha Emitters
TG72 RBE and Reference Animals and Plants
TG76 NORM
TG79 Use of Effective Dose
TG89 Occupational RP in Brachytherapy
TG90 Age-dependent Dose Conversion Coefficients for External Exposures
TG91 Low-dose and Low-dose Rate Exposure
TG93 Update of ICRP Publications 109 and 111
TG95 Internal Dose Coefficients
TG96 Computational Phantoms and Radiation Transport
TG97 Surface and Near Surface Disposal
TG98 Contaminated Sites
TG 99 Reference Animals and Plants Monographs
TG101 Radiopharmaceutical Therapy
TG102 Detriment Calculation Methodology
TG103 Mesh-type Computational Phantoms
TG104 Integration of Protection of People and the Environment
TG105 The Environment in the System of RP
TG106 Mobile High Activity Sources
TG108 Optimisation of Protection in Digital Radiography, Fluoroscopy, and CT
TG109 Ethics in RP in Medicine
TG110 Veterinary Practice
TG111 Individual Response to Radiation
Task Group 93 Draft Report

Application of the Commission’s Recommendations for the protection of people and the environment in the event of a large nuclear accident

- Update of Publications 109 and 111 -

1. Introduction
2. General Considerations
3. Emergency Response
4. Recovery
5. Emergency and Recovery Preparedness
6. Conclusions

Annex A. Chernobyl
Annex B. Fukushima
## Timeline of an Accident

<table>
<thead>
<tr>
<th>Preparedness</th>
<th>Emergency Response</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early phase</td>
<td>Intermediate phase</td>
<td>Long-term phase</td>
</tr>
</tbody>
</table>

**Emergency exposure situation**

**Existing exposure situation**

### Early phase:
Various protective actions need to be taken promptly

### Intermediate phase:
The source of the release has been stabilised
Focuses on characterising the radiological situation on-site and off-site

### Long-term phase:
On site when the source is considered secured enough and the exposure situation sufficiently stabilised
Off site when the radiological conditions in the affected areas are sufficiently characterised to support decisions by the authorities
Consequences of Large Nuclear Accidents

- Large nuclear accidents are complex situations
- All dimensions of individual and social life affected
- Situations cannot be managed with radiological protection considerations alone

- Other considerations:
  - Psychological
  - Health
  - Economic
  - Educational
  - Ethical
  - Environmental
  - Cultural
Emergency Response 1

Protection strategy for the early phase

- Immediate use of pre-planned strategy necessary
- Essential all relevant stakeholders involved in plan
- Decisions to modify emergency plan should only be taken if planned response proves inappropriate
- Those affected should be informed fully, quickly and continuously with regard to:
  - What is known
  - What is unknown
  - Reasons for recommended actions
Emergency Response 2

Protection strategy for the intermediate phase

- Active participation of stakeholders brings relevant local knowledge and experience to decision making
- Protection strategies more likely to be understood and supported
- Key issues should be addressed to characterise exposure situation
- Characterisation enables informed planning and implementation of longer terms actions
  - Detailed environmental monitoring
  - Long-term health surveillance
Emergency Response 3

Monitoring of individuals during the emergency

- Thyroid monitoring at early stage important for children and pregnant women

- Chernobyl and Fukushima accidents demonstrated value of putting individual exposure in context of other exposures

- Benchmarking individual exposure in a relevant context helps with understanding self-help
Termination of emergency protective actions

• Decision to terminate individual protective measures needs to reflect prevailing circumstances of the emergency exposure situation

• Termination decisions should be transparent, have due regard for the appropriate reference level and for stakeholder concerns whenever possible
## Protection of Emergency Responders

### Table 3.1. Reference levels for emergency responders

<table>
<thead>
<tr>
<th>Emergency exposure situation</th>
<th>Early phase</th>
<th>Intermediate phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-site</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dedicated teams (for radiological intervention)</td>
<td>100 mSv or below</td>
<td>100 mSv/y or below</td>
</tr>
<tr>
<td>Emergency teams (fire, police, rescue, medical)</td>
<td>Exceptional circumstances</td>
<td>May evolve with circumstances</td>
</tr>
<tr>
<td>Plant and outside workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Off-site</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency teams</td>
<td>100 mSv or below</td>
<td>n/a</td>
</tr>
<tr>
<td>Skilled workers</td>
<td>Exceptional circumstances</td>
<td>20 mSv/y or below</td>
</tr>
<tr>
<td>Other responders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Skilled workers and other responders may be subject to different exposure limits depending on the circumstances.
Recovery 1

• Management of an existing exposure situation following a nuclear accident relies on the implementation of an integrated and complex rehabilitation programme.

• Relevant radiological protection characterised by strategies that include:
  - actions implemented by authorities locally & nationally
  - self-help actions taken by affected population

• For managing long-term contamination, essential system of radiation monitoring and data dissemination are developed to select and implement appropriate protective actions.
Recovery 2

In the recovery phase:

- Individual life-styles become key factor to control radiation exposure of those living and working in affected area.

- Individual measurements with suitable devices critical to ensure development of practical radiological protection culture.

- Establishing process of co-expertise facilitates emergence of such culture in local communities.

- Practical RP culture is composed of information, practical knowledge and skills enabling people to judge for themselves the most appropriate approaches.
Health surveillance

- Main goal of a health surveillance programme to improve health and living conditions of potentially affected populations

- Development of health surveys and databases requires communication strategies and RP culture with empowerment of affected population

- Establish links with socio-economic support and dedicated education and training programme for health professionals
## Reference levels for optimising protection in case of nuclear accidents

<table>
<thead>
<tr>
<th></th>
<th>Emergency exposure situation</th>
<th>Existing exposure situation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public</strong></td>
<td>100 mSv or lower $^a$</td>
<td>10 mSv/y or lower $^{a,b}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The long term goal is to reduce exposures to the range of 1 mSv/y</td>
</tr>
<tr>
<td><strong>Responders</strong></td>
<td>100 mSv or lower $^a$</td>
<td>20 mSv/y or lower $^a$</td>
</tr>
<tr>
<td></td>
<td>Could be exceeded in exceptional circumstances $^c$</td>
<td></td>
</tr>
</tbody>
</table>

a) Previously the Commission recommended selection of reference levels in the band of 1-20 and 20-100 mSv or mSv/y. The current recommendation recognises that under some circumstances lower reference levels than 20 for emergency and 1 for existing may be appropriate. The optimisation of the thyroid dose from radioiodine should be differently applied. See 2.3.3.3.

b) This clarifies the previous recommendation of the Commission to select reference levels for the optimisation of protection of people living in contaminated areas in the lower part of the 1-20 mSv/y band. See 2.3.3.3.

c) The Commission continues to recommend to take all practicable actions to not exceed 1000 mSv to avoid severe deterministic effects for responders involved in exceptional circumstances during the emergency phase (Ref. ICRP Pub.118)
Three pillars of the system of radiological protection

- Science
- Ethics
- Experience

System of radiological protection
ICRP and Ethics

- ICRP Publication 138 issued in February 2018
- First publication dealing explicitly with the ethical dimensions underlying the system of radiological protection
- Daily implementation of the system of radiological protection is a matter of what philosophy used to call ‘practical wisdom’
Development of ICRP Publication 138

- Task Group of Committee 4 established 2013

- Exemplary process of stakeholder involvement organised in collaboration with IRPA
  - Series of 8 workshops held worldwide and discussions at both IRPA regional and international congresses and ICRP 2015 Symposium
  - Active contribution of more than 150 specialists of ethics and radiological protection professionals
The workshops on the ethical dimensions of the radiological protection system (1)

Daejeon, Korea, August 2013

Milan, Italy, December 2013

London, UK, June 2014

Baltimore, USA, July 2014
The workshops on the ethical dimensions of the radiological protection system (2)

Budweiz, Czech Republic, June 2014

Madrid, Spain, February 2015

Cambridge, USA, March 2015

Fukushima, Japan, June 2015
Ethical values underpinning the system of radiological protection

Core values

- **Beneficence/non-maleficence**: doing good and avoiding harm
- **Prudence**: if facing uncertainty, avoid unwarranted risks
- **Justice**: fair sharing of benefits and risks
- **Dignity**: respect of individual autonomy

Procedural values

- **Accountability**: to be responsible for one’s own action
- **Transparency**: to share available information
- **Inclusiveness**: stakeholder participation

Overall ethical goal is to contribute to the well-being of individuals and the quality of living together
Relationship between core ethical values and fundamental principles

- **Justification**: any decision that alters a radiation exposure situation should do more good than harm – Beneficence/non-maleficence

- **Optimisation**: all exposures should be kept as low as reasonably achievable (ALARA) with restriction on individual exposures (Reference levels) to limit inequity and the need to account for views and concerns of stakeholders – Prudence, justice, dignity

- **Limitation**: any individual dose should not exceed the level of exposure considered tolerable for workers and the public in planned exposure situations – Prudence, justice, dignity
The Optimisation Principle

- Optimisation principle said to be the cornerstone of the system of radiological protection since it governs decisions concerning protective actions taking account of:
  - Particularities of the exposure situation under consideration (economic and societal factors)
  - Views and concerns of stakeholders – inclusiveness
  - Most appropriate human, technical and financial means
  - Ethical values that govern radiological protection

- It is the process in which science, ethics and experience converge in order to choose wisely the best protective actions given the particular circumstances
The Optimisation Process
(ICRP Publication 101b - 2006)

Evaluation of exposure situations
to identify the need for actions

Identification of protective actions

Selection of the best action
under the prevailing circumstances

Implementation of the protective actions
The above skills are those that characterise what philosophy calls ‘practical wisdom’
By eliciting the ethical values that underpin the system of radiological protection, ICRP hopes professionals will gain a clearer view of the societal implications of their decisions.

In the long run, this should help improve dialogue with stakeholders.

Consideration of ethical aspects in practice should enrich the skills of radiological protection professionals.

Will require major effort to disseminate the content of Pub 138 as well as educational and training actions.
What next?

- Publication 138 considered by Commission a founding document
- Task Group 109 ‘Ethics in medical diagnosis and treatment of patients’ established April 2018
- Henceforth, all publications will seek to explicitly address the ethical dimensions of radiological protection where possible
- Other Task Groups concerning ethics of radiological protection may be considered in future for particular exposure situations if deemed necessary
TG102 Detriment Calculation Methodology

- Task Group of Committee 1 established in 2016

Mandate:

- Trace the history of detriment in ICRP
- Detail the calculation procedure and reproduce the calculations in Publication 103
- Assess the sensitivity of detriment to calculation parameters
- Identify potential improvements in the detriment calculation procedure

Solid basis for future recommendations
ICRP and the History of Detriment

• ICRP Publication 26 (1977)
  ‘The Commission has introduced the concept of detriment to identify, and where possible to quantify, all these deleterious effects. In general, the detriment in a population is defined as the mathematical “expectation” of the harm incurred from an exposure to radiation, taking into account not only the probability of each type of deleterious effect, but also the severity of the effect’

• ICRP Publication 45 (1985) revised index of harm

• ICRP Publication 60 (1991) estimates of fatal cancer with allowances for lethality and morbidity

• ICRP Publication 103 (2007) cancer incidence rather than mortality data
1. Calculation of lifetime attributable risk
2. Transfer of risk estimates across population
3. Application of a dose and dose-rate effectiveness factor (DDREF)
4. Sex-averaging
5. Integration of heritable effects

6. Adjustment for lethality
7. Adjustment for quality of life
8. Adjustment for years of life lost

- Baseline rates
- Survival function
- Cancer risk models
- Age distribution of the population
- Lethality fractions
- Quality of life factor
- Relative duration of life lost
# Detriment calculation

## Nominal risk and detriment for the general population (cases per 10 000 per Sv)

(from Tables A.4.1 and A.4.5, ICRP Publication 103, 2007)

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Nominal risk coefficient</th>
<th>Lethality fraction</th>
<th>Min weight for non-fatal cancers</th>
<th>Non-fatal case weight</th>
<th>Relative cancer free life lost</th>
<th>Detriment</th>
<th>Relative detriment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oesophagus</td>
<td>15</td>
<td>0.93</td>
<td>0.1</td>
<td>0.935</td>
<td>0.87</td>
<td>13.1</td>
<td>0.023</td>
</tr>
<tr>
<td>Stomach</td>
<td>79</td>
<td>0.83</td>
<td>0.1</td>
<td>0.846</td>
<td>0.88</td>
<td>67.7</td>
<td>0.118</td>
</tr>
<tr>
<td>Colon</td>
<td>65</td>
<td>0.48</td>
<td>0.1</td>
<td>0.530</td>
<td>0.97</td>
<td>47.9</td>
<td>0.083</td>
</tr>
<tr>
<td>Liver</td>
<td>30</td>
<td>0.95</td>
<td>0.1</td>
<td>0.959</td>
<td>0.88</td>
<td>26.6</td>
<td>0.046</td>
</tr>
<tr>
<td>Lung</td>
<td>114</td>
<td>0.89</td>
<td>0.1</td>
<td>0.901</td>
<td>0.80</td>
<td>90.3</td>
<td>0.157</td>
</tr>
<tr>
<td>Bone</td>
<td>7</td>
<td>0.45</td>
<td>0.1</td>
<td>0.505</td>
<td>1.00</td>
<td>5.1</td>
<td>0.009</td>
</tr>
<tr>
<td>Skin</td>
<td>1000</td>
<td>0.002</td>
<td>0.0</td>
<td>0.002</td>
<td>1.00</td>
<td>4.0</td>
<td>0.007</td>
</tr>
<tr>
<td>Breast</td>
<td>112</td>
<td>0.29</td>
<td>0.1</td>
<td>0.365</td>
<td>1.29</td>
<td>79.8</td>
<td>0.139</td>
</tr>
<tr>
<td>Ovary</td>
<td>11</td>
<td>0.57</td>
<td>0.1</td>
<td>0.609</td>
<td>1.12</td>
<td>9.9</td>
<td>0.017</td>
</tr>
<tr>
<td>Bladder</td>
<td>43</td>
<td>0.29</td>
<td>0.1</td>
<td>0.357</td>
<td>0.71</td>
<td>16.7</td>
<td>0.029</td>
</tr>
<tr>
<td>Thyroid</td>
<td>33</td>
<td>0.07</td>
<td>0.2</td>
<td>0.253</td>
<td>1.29</td>
<td>12.7</td>
<td>0.022</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>42</td>
<td>0.67</td>
<td>0.1</td>
<td>0.702</td>
<td>1.63</td>
<td>61.5</td>
<td>0.107</td>
</tr>
<tr>
<td>Other solid cancers</td>
<td>144</td>
<td>0.49</td>
<td>0.1</td>
<td>0.541</td>
<td>1.03</td>
<td>113.5</td>
<td>0.198</td>
</tr>
<tr>
<td>Gonads (heritable)</td>
<td>20</td>
<td>0.80</td>
<td>0.1</td>
<td>0.820</td>
<td>1.32</td>
<td>25.4</td>
<td>0.044</td>
</tr>
<tr>
<td>Total</td>
<td>1715</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>574.2</td>
<td></td>
</tr>
</tbody>
</table>

\[
D = [(R \times k) + (R \times (1 - k) \times q)] \times l
\]

\[
q = (1 - q_{\text{min}}) \times k + q_{\text{min}}
\]
Detriment calculation

Reproducing the detriment calculation procedure of the ICRP Publication 103

- Allowed to resolve ambiguities in the calculation procedure (lifetime risk calculation method, lag time, lifetime age, transfer weighting...)
- Identified needs for updates (baseline rates, risk models, lethality fractions...)
- Identified lack of internal consistency (WT for cancers of the brain and of salivary glands without risk calculation...)
- Highlighted difficulties in understanding the meaning of detriment
Sensitivity analyses showed:

- Limited sensitivity of detriment to latency, lifetime age, lifetime risk calculation method or quality of life
- Noticeable sensitivity to gender and population for certain cancer types
- Large sensitivity of detriment with DDREF, age-at-exposure, transfer model (100% ERR or 100% EAR model) and lethality
Calculation of radiation detriment

- Concept first introduced in ICRP Publication 26 (ICRP, 1977)
  Methodology and scope has been evolving over time to consider new scientific knowledge about health effects of radiation exposure at low doses

- Calculation process consists of two main parts:
  - 1. based on the modelling of cancer radiation-induced risks
  - 2. based on the health consequences of cancer

- Complex calculation process implying a certain number of input data, parameters, calculation steps, and underlying hypotheses, which need to be clearly and fully documented

- Detriment is an integrated health risk indicator, calculated as a sex, age and population weighted mean and the severity-adjusted lifetime risk attributable to radiation exposure
Detriment Summary

Suggestions for potential future improvement

• To evolve depending on progress in scientific understanding of radiation health effects and the evolution of cancer consequences
  ➢ To update and improve reference population data and cancer severity parameters
  ➢ To consider new cancer risk models (LSS and other epidemiological studies, risk models for bone, skin, brain, salivary glands cancers)
  ➢ To consider and justify whether or not to include non-cancer effects in radiation detriment

• To calculate detriment for both sexes and selected ages, and to average only at the last step

• To consider low dose exposure scenarios

• To ensure transparency and traceability of detriment calculation, and to improve understanding by non-specialists
ICRP Evolution

From 1928…

Missing Giulio Ceresole

…To 2018
ICRP 2009

- Mainly elderly males ('Old Boys’ Club')
- Lack of transparency ('The ivory tower')
ICRP Evolution

- Established biennial symposia
- Established Special Liaison Organisations
- Written Strategic Plans
- Held open nominations for Committee members (25% change each term)
- Change of publisher from 2013
Relations with other Organisations

IEC Nuclear Instrumentation (IEC/TC45)

IEC Electrical Equipment in Medical Practice (IEC/TC62)
ICRP Evolution

• Developed ICRP Code of Ethics
• Strengthened Secretariat
• Changed Constitution
• Organisational restructure with four Committees instead of five
• Updated website
Protection of the Environment

• Several publications trace development from initial framework to information for implementation

• Protection of the environment will now be fully integrated into the one system of radiological protection
90th Anniversary Drive to Free the Annals

- Currently: First 60 years Publications (1928-1988) and last general recommendations
  *Publication 103* free of charge

- Goal: make all ICRP publications freely available (except most recent rolling two years)

- Needed: €500,000
“Don’t judge a book by its cover”
Coming Soon

ANNALS OF THE ICRP

PUBLICATON 140

Radiological Protection in Therapy with Radiopharmaceuticals

Volume 41 No. 1, 2019

ISBN 0146-6430 • ISBN 9781266434812

ANNALS OF THE ICRP

PUBLICATON 141

Occupational Intakes of Radionuclides: Part 4

Volume 41 No. 2-4, 2019

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