

Science and Values in Radiological Protection: Challenges and Opportunities

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Background

- 2007: “**Scientific Issues and Emerging Challenges for Radiation Protection**” by CRPPH Expert Group on the Implications of Radiological Protection Science (EGIS)
- 2007: “**Radiation Protection in Today’s World - Towards Sustainability**” by CRPPH Expert Group on the Collective Opinion (EGCO)

Science and Values in RP

- Both science and societal values play a role in decision making, particularly in circumstances of significant scientific uncertainty
- The CRPPH wanted to explore how science and values are “mixed” when making decisions, and from this infer better approaches to managing and directing scientific research in support of decision making, and to making socially and scientifically informed regulatory decisions

Approach

- To achieve this, the CRPPH developed a workshop to explore Science and Values in Radiological Protection
- The workshop was based on case studies of state-of-the-art RP science
- Based on “best estimate” scientific knowledge, specific “what if” assumptions were made in breakout sessions
- These “what if” situations formed the basis for breakout discussions

Workshop format

- Plenary session
- Discussion of Values in RP Decision Making
- Breakout sessions, moderated discussions
 - non-targeted effects
 - individual sensitivity
 - circulatory diseases
- Reports from breakout groups
- Summary discussion

Questions to breakout groups

- Why is discussing non-targeted effects / individual sensitivity / circulatory diseases relevant?
- What do we know about NTE / IS / CD?
- What do we NOT know that we would like to know?
 - What are the scientific issues?
 - What are the regulatory issues?
- What approach(es) should be followed to address the scientific issues raised?
- What would we do differently if we knew what we would like to know?
- What could or should we do now while we wait for the answers to these questions?

Non-targeted effects

Breakout session 1

Why are non-targeted effects a relevant topic?

- They may modify the dose response at low dose region; detriment may not be proportional to dose
- They may give mechanistic explanations to effects other than cancer (tissue responses)

What do we know about NTE?

- Bystander effects are seen in cells not directly hit by radiation;
- Genomic instability is induced in the progeny of exposed cells
- Amplifying the radiation response, target size bigger than that hit by radiation
- They have been shown both in vitro and in vivo; a variety of effects (mutation, apoptosis, gene expression....)
- Dose response is non-linear

What do we not know that we would like to know

- We do not know the link between BE, GI and health effects
- We do not know the nature of signals transmitting NTE
- Is genomic instability an epigenetic effect?
- Genomic instability is a permanent event, produced by ionising radiation but also by other agents

What approaches should be followed to address the scientific issues raised?

- Studies of mechanisms at cellular and tissue level
- Modeling of experimental data to address extrapolation issue
- Animal experiments
- Molecular epidemiology? Biomarkers of effect?

What would we do differently if we knew what we would like to know?

- Are damage and repair mechanisms the same?
(at doses higher than 100 mSv, lower than 100 mSv)
This would affect how doses are assessed and protection is chosen
- Is extrapolation valid?
This would affect how “high” and “low” doses are assessed

What could or should we do now while we wait for the answers to these questions?

For the moment, there is no need to change, BUT:

- A gap between NTE and consequences in health-effect terms still exist, ***we don't know if NTE lead to health effects***
- For regulators, it is important to know whether a link exists between NTE and mutation, because we know that there is a link between mutation and cancer
- ICRP 2007 recommendations accept that in some situations LNT could be not the best model, even if it remains the best tool for RP management
- Are NTE linked to non-cancer diseases ..?

Individual sensitivity

Breakout session 2

Why do we care about Individual Sensitivity?

- This IS an issue at high doses (radiation therapy)
- Not known whether it is an issue at low doses
- If we knew that there were hyper-sensitive individuals, this would be an issue, but it is not reasonable to act unless you know more about WHO is hyper-sensitive (how large a group), and how hyper-sensitive they are
- These issues may pose ethical and regulatory challenges to the current approach to RP
- We know that:
 - Women are approximately twice as sensitive as men
 - Children are 5 to 10 times more sensitive than adults
 - The embryo and fetus are more sensitive than children or adults

What do we KNOW now about Individual Sensitivity?

- 'low dose' means levels experienced by workers and public
- 'high dose' refers here to patients undergoing radiation therapy
- About 5% of patients are hypersensitive to radiation
 - We will probably have a predictive test to identify such people in the not-too-distant future
- It is suspected that there are patients who are hypo-sensitive to radiation, but the size of this group is not known
- There are differences in cell sensitivity

What do we KNOW now about Individual Sensitivity?

Low dose considerations (diagnostic, occupational, public exposure levels)

- We know that cellular response is quantitatively and qualitatively different at high and low doses
- There is limited epidemiological evidence of effects below 100 mSv in adults, and 50 mSv in children
- We know that there are non-targeted effects at very low doses, but we do not know what the consequences of this may be
- Classical epidemiology has not and can not provide any evidence of individual sensitivity

What do we NOT KNOW now about Individual Sensitivity that we WANT to know?

High dose considerations

- Need to know more about mechanisms and consequences/applicability of effects caused by hypersensitivity
- We need models and predictive tests to better understand the risk of secondary tumors from therapy: e.g.
 - at what range of exposures these may occur?
 - what is the age-at-exposure effect?

Science Issues: Where we need more information

- Need more info on age and gender dependence (particularly at low doses)
- What fraction of the population is genetically highly sensitive? What are their distributions (geographic, shape of distribution curve, etc.)
- How much more sensitive are they?
- Does high-dose sensitivity imply low-dose sensitivity? Can this be experimentally explored?

Regulatory Issues: Where we need more information

- Does our current approach to RP (limits, etc.) ALREADY protect hypersensitive people?
- Should we need to change the RP regulatory approach, would it be best to:
 - Lower dose limits for all ?
 - OR –
 - Re-evaluate protection approaches for sensitive individuals from high-exposure work?
 - The choice will in part depend on the size of the sensitive population, the level of its sensitivity, and the ease and validity of identifying sensitive individuals

What would we do differently IF we knew now what we would like to know?

IF we:

- Have a tool to predict individual sensitivity
- Know how many people are more sensitive, and what is their sensitivity distribution
- Know how much more sensitive they are
- Know the relationship between sensitivity to acute effects and stochastic effects
- Know whether low-dose effects are negative, positive or both
- Know the effect of dose rate

What would we do differently IF we knew now what we would like to know?

At high dose in therapy:

- Would need to develop clinical guidelines to improve Individual patient treatment

At high doses in emergency situations

- Triage of victims in terrorist events or large accidents would improve
- Emergency workers could be pre-selected for their resistance :
 - Separate dose restrictions could be developed for this group, although this would raise ethical and labour questions

What would we do differently IF we knew now what we would like to know?

At low dose in the workplace:

- If the increase (or decrease) in sensitivity is low (e.g. on the order of the factor of 2 but within the current range of RP uncertainty) there would be a need to assess the costs and benefits of change to the current RP or labour management approach (SI)
- If the increase (or decrease) in sensitivity is large (e.g. on the order of one or two orders of magnitude) the employer may have a duty to inform about the existence of the test, to test workers, and inform them of the results.
- Start with existing international text on genetic discrimination

At low dose to the public:

- The issues that would need to be addressed would include:
 - Education and information of the public
 - Availability of genetic susceptibility test results - interpretation
 - Implications for insurance, employment
 - Implications for people living in high-background areas
 - Medical diagnostic or screening campaigns
 - Need to re-evaluate dose limits
 - Implications for the optimisation of protection
 - Consider consequences of other possible sensitivities (e.g. to UV)

Circulatory diseases

Breakout session 3

Why do we care about the problem?

- Existence of clear epidemiological evidence above 0.5 Gy for the radiation induced cardiovascular diseases (CD), at lower doses the evidence is inconclusive
- Radiation induced CD may have significant impact on the morbidity and mortality
- CD are currently not specifically addressed by the system
- Public and trade unions concerns are increasing

ICRP position

- **Statistical evidence**
 - Induction of effects around 1 Sv
 - Association with dose
- **Uncertainties on the shape of the dose-response at low doses**
 - Data consistent with there being:
 - No threshold
 - Threshold at 0.5 Sv
- **Judgement**
 - *"Data available do not allow for their inclusion in the estimation of detriment following low radiation doses less than 100 mSv. This agrees with the conclusion of UNSCEAR 2008 which found little evidence of any excess of risk below 1 Gy" (ICRP)*

To address this issue within RP now ..

- **Pros**

- existing evidence above 0.5 Gy
- coherence with philosophy of RP
- ethical and moral aspects
- public concern, RP is responding and aware of the problem
- incentive to improve some practices and technologies causing high exposure

- **Cons**

- below 0.5 Gy see nothing, lack of knowledge (mechanisms - cellular, molecular, ...?)
- magnitude of rad. effects on CD is small compared to other causes considered in public health
- unable to quantify cost/benefit associated with potential decrease of dose limits, the benefit may be nil if there is a threshold
- new epidemiological studies coming fairly soon
- public concern: potential distrust for not having identified the problem earlier

What further do we need to know?

1. Mechanism: elucidation on possible mechanism (inflammatory / micro vascular, mutation, others?)
 - Inflammatory is more plausible (experiments ongoing)
 - Different mechanisms at high and low doses?
2. Are these mechanisms consistent with stochastic or deterministic dose response
 - Inflammatory consistent with deterministic
 - If the threshold is low, there may be a need for change in RP
3. Epidemiological data below 0.5 – results of ongoing studies and need for launching further studies (e.g. CT)
4. Does the relative risk depend on type of CD?
5. How does the spectrum of radiation induced CDs depends on dose?
6. Dose and dose-rate effect and radiation quality?
7. Age, gender, population and temporal effects?
8. Synergistic effects, interactive effects with other agents?
9. What is the target tissue?

What would we do differently IF we knew now what we would like to know?

- If change is made based on Japanese risk estimates and LNT, the detriment would increase 50-100%
- This might lead to decrease of current dose limits by 30-50% and emphasis on optimization
- Application of precautionary principle should include not only the change in detriment but also the cost and other consequences associated with this change
- Medical exposures (CT) are at least 100 times higher than occupational ones, and are typically excluded from the limits
- Any regulation currently applied is unlikely to have an observable benefit

What are we doing now?

- Reinforcing scientific studies on the given subjects
- Increasing professional awareness of the issue
- Critically reviewing existing data/literature
- Challenging features of the current RP system in light of evolving science and value judgements

Science and Values in RP: a fresh look at an old issue?

“Radiation protection is not only a matter for science. It is a problem of philosophy, and morality, and the utmost wisdom.”

Lauriston R. Taylor (1902-2004)

The Philosophy Underlying Radiation Protection, Am. J. Roent. Vol. 77, N° 5, 914-919, 1957.

“The establishment of maximum permissible radiation levels is a non scientific task, which must be based primarily on scientific knowledge and judgement.”

Rolf M. Sievert (1896-1966)

The Work of the International Commission on Radiological Protection, United Nations Conference

on The Peaceful Uses of Nuclear Energy, Geneva, 1-13 Sept. 1958, Vol. 21, Session 5a, pp. 3-7

The development of the Scientific Basis for Radiological Protection should not mean less but more discussion on Values

Science and Values: room for improvement

Paradoxical situation where ICRP recommendations:

- seen as evolving mostly on the basis of science
- not recognizing the influence of NGOs, discarding findings they use
- yet on a global trend of increase of protection

Relevance to implement a real dialogue - including:

- > implement new processes and deal with statutory concerns to develop **confidence in the system**
- > show **consideration** and discuss the potential influence of NGOs values on global concepts and principles
- > get stakeholders involved in the **evaluation** of scientific evidence and the definition of further research needs
- > set periodical **review of the implementation** with stakeholders

Science and Values: a way forward

Three specific topics discussed in Helsinki have all demonstrated:

- uncertainty prevails and ethical / regulatory issues arise
- “what if” mode is a relevant way to discuss scientific findings from the perspective of values

⇒ Need to share **understanding**, develop a **pluralistic evaluation** and discuss the **potential consequences** in terms of principles and implementation

Same applies to the protection of the environment

Key to success is to **further develop the focus on values**:

- topic(s) of next workshop(s) should put more emphasis on issues of values
- appropriate preparation must ensure that a significant number of stakeholders get effectively involved (independent experts, NGOs informed representatives...)