ASSESSMENT AND MANAGEMENT OF RISK FROM RADIOLOGICAL HAZARDS

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Health Canada Risk Assessment/Risk Management Framework

Risk Assessment

- Risk Analysis
  - Hazard Identification
  - Risk Estimation

- Option Evaluation
  - Development of Options
  - Option Analysis

Risk Determination

Risk Management

- Decision
- Implementation
- Monitoring and Evaluation
- Review
RADIATION PROTECTION STRATEGY

• Risks and benefits of radiation recognized early
• Risk reduction strategies developed in parallel with use
• Balance risks and benefits
• Evolved with new knowledge
• Strategy contains elements of HC and workshop framework
RISK ASSESSMENT – HAZARD

• Ionizing radiation
• Natural and artificial sources
• ~ 50 radionuclides of concern
  ▪ abundance
  ▪ toxicity
• Deposit energy in matter – chemical changes cause biological damage
• Damage caused by well-understood mechanisms
# SHORT-TERM EFFECTS OF RADIATION EXPOSURE

<table>
<thead>
<tr>
<th>Dose (Sv)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Chromosome changes (threshold)</td>
</tr>
<tr>
<td>0.5</td>
<td>Blood count changes</td>
</tr>
<tr>
<td>1</td>
<td>Vomiting</td>
</tr>
<tr>
<td>1.5</td>
<td>Mortality (threshold)</td>
</tr>
<tr>
<td>3-5</td>
<td>$L_{D50}$</td>
</tr>
<tr>
<td>8</td>
<td>100% mortality</td>
</tr>
</tbody>
</table>
LONG-TERM EFFECTS OF RADIATION EXPOSURE

- Appear years later (5 years to a lifetime)
- Likelihood of occurrence depends on amount of radiation received
  - **CANCER** (leukemia, thyroid, lung, bone, breast, skin, other tumours)
  - *In utero effects* (effects on developing baby caused by exposure of the mother during pregnancy)
  - **Genetic effects** (effects on future generations caused by exposure of either parent before conception)
RISK ASSESSMENT - ESTIMATION

- Based on long-term follow-up studies of human populations exposed to high doses of radiation
  - Survivors of atom bombs in Japan
  - Uranium miners exposed to radon
  - Radium dial painters
  - Patients treated with high doses of x-rays or radionuclides

- At lower dose need appropriate dose response model to extrapolate from high-dose effects

- Additional information from experiments on animals

- Considerable uncertainty at low levels – extrapolate beyond conditions under which data originally collected
• Risk estimates made by:
  ▪ United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
  ▪ International Commission on Radiological Protection (ICRP)
  ▪ United States Committee on the Biological Effects of Ionizing Radiation (BEIR)
• Estimates based on rigorous science, peer-reviewed publications
• Estimates by committees in good agreement
DOSE RISK MODEL

- Linear no-threshold (LNT) hypothesis:
  - There is no “safe” level of radiation exposure
  - All exposures carry some level of risk
  - The risk is directly proportional to the exposure
- Form of Precautionary Principle
RADIATION RISK FACTOR

• Estimate of probability of radiation-induced cancers
• Based on extrapolations
• ICRP recommends:
  • For each Sievert of exposure to radiation in the general population, risk of fatal cancer is 5% or:
    5 cases per 100 people
  • Therefore at 1 mSv the fatal cancer risk is:
    50 cases per 1million people
RISK MANAGEMENT

- Strategy based on balance of risks and benefits
- ICRP – internationally recommended system of radiological protection
- Three basic principles
  - Justification – net benefit to society
  - Optimization – ALARA
  - Dose limitations
• Laws and regulations
  ▪ Nuclear Safety and Control Act
  ▪ Radiation Emitting Devices Act
• ICRP dose limits adopted by CNSC
  ▪ occupational and public exposures
  ▪ legal purposes
  ▪ not exceeded
• Limits:
  ▪ Occupational – 100 mSv over 5 years, 50 mSv in a year
  ▪ Public – 1 mSv in a year

• Ensures no one exposed to unacceptable radiation risks
• Control at source for regulated practices

• Nuclear facilities apply ALARA – achievable levels – lower than legal dose limit

• Risk limited through ICRP recommendations, implementation by licensee and regulation by CNSC
• BEIR VII
  ▪ Supports previous risk estimates
  ▪ Strengthens confidence in estimates
  ▪ Supports linear no threshold risk model
  ▪ Recommends additional epidemiological research
CONCLUDING REMARKS

- Challenge to develop programs to protect workers, public and environment
  - gaps in knowledge
  - uncertainties
- Uncertainty in risk estimates at doses < 50 mSv
- Precautionary approach in establishing strategies
- Absorbed dose – amount of energy deposited by radiation in tissues and organs.
  - Independent of type and energy
- Extent of radiation damage depends on:
  - radiation type
  - organ sensitivity
- Weighting factors developed to account for variability
  - Effective Dose