LUNG CANCER FROM EXPOSURE TO RADON

Based on the UNSCEAR 2019 Report to the General Assembly (A/74/46)

Borislava Batandjieva-Metcalf, Secretary of UNSCEAR
Per Strand, Chair of UNSCEAR’s Radon Expert Group

IAEA Technical Meeting on the Implications of the New Dose Conversion Factors for Radon, Vienna, 1-4 October 2019
• Background
• Aims, objectives and scope
• Results
• Future research needs
• Concluding remarks
Established by UN General Assembly resolution 913 (X) in 1955

Compile and assess all available scientific data:
- Levels of ionising radiation and radioactivity in the environment
- Scientific information on effects and risks of ionizing radiation

Report on scientific observations and experiments
- Improve knowledge and understanding of levels and effects
- Identify areas for future research
- Disseminate findings to General Assembly, scientific community and public
Background: UNSCEAR members

- Scientists from 27 UN Member States and 4 Observers*

- Algeria*
- Argentina
- Australia
- Belarus
- Belgium
- Brazil
- Canada
- China
- Egypt
- Finland
- France
- Germany
- India
- Indonesia
- Iran (IR)*
- Japan
- Mexico
- Norway*
- Pakistan
- Peru
- Poland
- Rep. of Korea
- Russia
- Slovakia
- Spain
- Sudan
- Sweden
- Ukraine
- UAE*
- UK
- USA

Other Member States and international organizations provide relevant data
UN General Assembly (74th meeting, 2019)

- Reports annually

UNSCEAR Committee
- Expert Groups:
  - Lung Cancer due to Radon
  - Selected health effects
  - Medical exposure
  - Occupational exposure
  - Biological mechanisms
  - Fukushima II assessment
  - Public exposure (new)
  - Second primary cancer (new)
  - Epidemiological studies (new)

Bureau
- Ad hoc WGs:
  - Effects and mechanisms
  - Sources and exposure (new)

UNEP

Administration

Secretariat
International radiation safety regime

**UNSCAR Scientific basis**

**ICRP**
Protection philosophy, principles and units

- Protection issues
- Effects on health
- Risks

**ILO convention 115:**
occupational radiation protection

**FAO/WHO Codex Alimentarius Commission**
(food contamination guides)

**UN transport regulations for radioactive material**

implemented by UN Member States
Dose conversion coefficients from concentration to dose (mSv)

**UNSCEAR Report 1988**

136. The dosimetry of radon and its decay products is at present under review, and uncertainty prevails about a conversion coefficient suitable for deriving the effective dose from the concentration. In this Annex, the effective dose coefficient that was adopted in the UNSCEAR 1988 Report for inhalation of radon progeny has been kept; in numerical terms, the effective dose from 1 Bq h m\(^{-3}\) radon EEC is estimated to be 9 nSv for both indoor and outdoor exposures. The

9 nSv per Bq.h.m\(^{-3}\) Rn EEC \(\sim 5.7\) mSv (WLM)\(^{-1}\) to 1.6 mSv per mJ h m\(^{-3}\)

(Confirmed later in 2000 and 2006 Reports)
CHAIR:
P. Strand (Norway)

SECRETARIAT:
F. Shannoun

MEMBERS:
J. Chen, P. Demers, L. Zablotska (Canada), L. Tomasek (Czechia), A. Auvinen (Finland), E. Rage (France), N. Fenske (Germany), W. Standring (Norway), J. Marsh (UK), B. Smith (USA)

CRITICAL REVIEWERS:
M. Tirmarche (France), M. Kreuzer (Germany), N. Harley (USA)

MEETINGS:
2 face-to-face meetings (Vienna in January 2018 and Paris in October 2018)
> 25 online meetings
The Committee has last studied issues concerning exposure and effects from radon and progeny in 2006. Between 2006 and 2016 there have been several hundred scientific publications concerning radon exposure and lung cancer, including those related to epidemiological studies of lung cancer in exposed populations as well as relevant dosimetry.

At its 63rd session in 2016, the Committee agreed to conduct a project on lung cancer from exposure to radon that would thoroughly assess recently published literature on this topic.

The work started in 2017 and is in agreement with the Committee’s mandate from the General Assembly of the United Nations for estimating effects and risk from radiation exposure, aimed to thoroughly assess newly available literature.
Aim and Objectives

• The original aim of the project was to clarify the approaches to assessing doses and risks of lung cancer from exposure to radon and thoron, based on the best and most up-to-date knowledge (including the risks from radon and thoron exposure and the risks from external exposure, and developments in dosimetry).

• The focus on thoron and penetrating radiation was reconsidered during the project due to the lack of new information on these topics.
The project reviewed the results of primary peer-reviewed studies published in the scientific literature and publications of relevant international organizations, such as ICRP, ICRU and WHO/IARC.

The focus was on epidemiological studies and dosimetric analysis. The main health effect of interest was lung cancer.

The review did not focus on assessing population exposure levels to radon (and thoron), which will be assessed in a public exposure survey to be completed in the future.

– Public Exposure Evaluation planned for 2020-2023!
• Defined research questions and scope of the literature review.
• Identified search keywords for online search engines in order to compile a master list of articles.
• Defined screening and quality questions to be applied to articles in the master list in order to identify those for which in-depth reviews will be performed.

Initial literature review (example):
• Dosimetry
  – 98 articles identified, 94 accepted for review
• Epidemiology
  – 262 articles identified, 176 accepted for review
Dosimetry results

<table>
<thead>
<tr>
<th>Radon progeny in homes</th>
<th>Dose conversion factor (DCF)</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mSv/WLM</td>
<td>nSv per h Bq m⁻³ of EEC</td>
<td></td>
</tr>
<tr>
<td>Arithmetic mean</td>
<td>11</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Geometric mean</td>
<td>10</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>4 to 21</td>
<td>7 to 34</td>
<td></td>
</tr>
</tbody>
</table>

Mean dose conversion factor from dosimetry publications for indoor conditions is 18 nSv per h Bq m⁻³ [Range 7-34], which is consistent with 15 nSv per h Bq m⁻³ in the UNSCEAR 2006 Report.
• Five newly published residential studies
• Mean ERR of 0.13 per 100 Bq m⁻³ [Range -0.13-0.73]
• New studies are small relative to pooled studies reviewed in UNSCEAR 2006 Report and give similar results.
• The Committee continues to support the UNSCEAR 2006 adopted European pooling study ERR estimate of
  
  – **0.16** [95% CI: 0.05-0.31] per 100 Bq m⁻³

  → **1.21** [95% CI: 0.38-2.35] per 100 WLM
## Epidemiology results

<table>
<thead>
<tr>
<th></th>
<th>ERR per 100 WLM</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Estimated</td>
<td>95% CI</td>
<td>Range</td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European pooling</td>
<td>1.21</td>
<td>0.38-2.35</td>
<td></td>
</tr>
<tr>
<td><strong>Occupational (entire cohorts)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>0.60</td>
<td>0.34-0.87</td>
<td>0.19-2.20</td>
</tr>
<tr>
<td><strong>Recent work periods/low exposure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>1.53</td>
<td>1.11-1.94</td>
<td>1.1-3.08</td>
</tr>
</tbody>
</table>

- Seven newly published occupational studies
- Combined ERR estimated with inverse variance weighted meta-analysis
- Entire cohorts result similar to UNSCEAR 2006 Report estimate of
  - 0.59 per 100 WLM [95% CI: 0.35-1.0]
- Higher ERR estimated for sub-cohorts with recent work periods/low exposures
  - Better exposure assessment → lower bias
  - Fewer subjects → lower precision
Epidemiology results

Lifetime excess absolute risk (LEAR) per WLM, according to BEIR VI exposure-age-concentration model for a constant exposure scenario of 2 WLM per year from 18 to 64 years of age (miner studies):

<table>
<thead>
<tr>
<th>Cohort</th>
<th>BEIR VI</th>
<th>Eldorado</th>
<th>Wismut</th>
<th>Czech</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAR per 10^4 Person per WLM</td>
<td>5.5 (1.4)</td>
<td>7.5 (3.9)</td>
<td>2.4 (0.6)</td>
<td>3.9 (1.0)</td>
</tr>
</tbody>
</table>

Other models investigating effects of exposure rate/periods of exposure using all exposures from low exposure rates are part of the electronic attachment.

<table>
<thead>
<tr>
<th>Cohort</th>
<th>BEIR VI</th>
<th>Ontario</th>
<th>Wismut</th>
<th>Czech</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAR per 10^4 Person per WLM</td>
<td>7.0 (1.5)</td>
<td>6.7 (1.7)</td>
<td>3.2 (0.6)</td>
<td>4.5 (1.1)</td>
</tr>
</tbody>
</table>
Uncertainty or imprecision in risk estimates can result from dosimetry and from epidemiology due to a number of factors:

- **Choice of dosimetric model**
- **Parameters and values used**
  - Breathing rates
  - Inhaled activity particle sizes
  - Airway particle deposition
  - Airway particle clearance
  - Target cell depth
- **Measurement errors in exposure assessment**
  - Seasonal and year-to-year variation in radon concentrations
  - Variability in radon concentrations from room to room
  - Missing measurements (incomplete coverage), imprecision in imputed or predicted/modelled exposure
  - Impact of thoron
- **Uncontrolled confounding by smoking and other risk factors**
Future Research Needs

• **Improve risk estimates** by understanding:
  – **Smoking versus non-smoking** on incidence of lung cancer attributable to radon exposure for subgroups of different age and sex as well as for different working/living conditions;
  – **Confounding factors** such as asbestos, silica, diesel exhaust fumes, nickel, chromium, lead and wood dust;
  – **Modifying effects** such as childhood exposure, exposure rate, time since exposure and attained age.

• **Analyses uncertainties** to cover further risk and exposure estimates.

• **Impact of thoron** (e.g., lung cancer from thoron exposure/interference with radon measurement).
• The Committee confirmed its previous conclusions that inhalation of radon and its decay products is carcinogenic mainly for the lungs.

• The Committee acknowledged that conversion factors for calculating the dose from a given exposure to radon are needed (1) for radiation protection purposes, which is in the mandate of other international bodies; and (2) for comparison purposes with other sources of radiation exposure, which is in its own mandate.

• The Committee further recommends, when estimating the impact of radon exposure levels in a population, to use of the general dose conversion factor of 9 nSv (h Bq m\(^{-3}\))\(^{-1}\) EEC of \(^{222}\)Rn, which corresponds to 1.6 mSv per mJ h m\(^{-3}\) or (5.7 mSv WLM\(^{-1}\)) because of the fact that the values from the current dosimetry and epidemiological reviews are consistent with those used in previous UNSCEAR reports and the uncertainties of risk estimates are large.

• The Committee commends to improve risk estimates by better understanding of the impact of thoron, smoking and other confounding and modifying factors.

• The Committee will continue its general review of population exposure to radon, with a focus on the consequent risk of lung cancer.
Printed version can be ordered from https://unp.un.org
Electronic version for free download www.unscear.org
Thank you for your attention!