WHO International Radon Project: 
Rationale and current results

Radiation and Environmental Health Programme
Public Health and Environment Dept.
Health Security and Environment Cluster

Hajo Zeeb, University of Mainz (formerly: WHO)
WHO IRP coordination team
Radon – why is WHO involved?

- Scientific evidence suggests 6-15% of lung cancers are due to exposure to indoor radon (second after smoking)
  - Globally > 70,000 cases (up to 170,000 cases) annually
  - Direct evidence from case-control studies on indoor radon

- WHO Member States say: people and politicians are not taking enough notice of this problem.

- Prevention & Mitigation are (relatively) easy

- WHO can bring together many countries for joint international approach to reduce radon health effects and help raise awareness among the public
Ionizing Radiation Projects and Issues

Existing sources – natural radiation, radon, cosmic radiation

Chronic exposures from past accidents – Chernobyl, depleted uranium

Planned exposures – medical, occupational

Accidental exposures – incidents, deliberate events

Emerging new technologies – research, evidence base
Radon health risks

- Environmental / occupational exposures
  - Observation of frequent lung cancer in mine workers
  - First indoor air radon measurement reported in 1902

- Initial epidemiological evidence from miners’ studies
  - Principal health risk: lung cancer
  - Also studied: leukemia, many other health effects

- Usual indoor exposures much lower, but: more people affected
  - Dedicated indoor studies in Europe, North America, China, other countries
  - Overall consistent risk estimates
European Studies Risk estimates

- Lung cancer risk increased by 8.4% per 100 Bq/m³ increase in measured radon concentration

After corrections:

- Lung cancer risk increased by 16% per 100 Bq/m³ increase in (corrected) radon concentration

Darby et al 2005
WHO International Radon Project

- **Scope:**
  
  A global project, with key international and national partners

- **Purpose:**
  
  To reduce the population disease burden due to radon in homes

- **Initial project time frame:** 2005 - 2007
WHO IRP: Objectives

- Identify effective strategies for reducing the health impact of radon

- Promote sound policy options, prevention and mitigation programmes (incl. monitoring & evaluation of programmes)

- Raise public, political and economical awareness about the consequences of exposure to radon (incl. financial institutions as target group)

- Estimate the global health impact of exposure to residential radon using available data on radon worldwide
<table>
<thead>
<tr>
<th>WHO International Radon Project members: 35 countries</th>
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<tbody>
<tr>
<td>• Albania</td>
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<td>• Argentina</td>
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<td>• USA</td>
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<td>• Ukraine</td>
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<td>• United Kingdom</td>
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</tbody>
</table>
Collaborations and Interface

- **EC**
  - Joint research centre JRC ISPRA (Gregoire Dubois)
  - Radon surveys in Europe

- **International Atomic Energy Agency IAEA**
  - Safety Guide on protection of the public from natural sources of radiation (in preparation, joint publication)

- **UNSCEAR [report on radon] (Doug Chambers)**

- **National radon activities and institutions**
  - National radon events and meetings
WHO IRP: Deliverables

- **WHO Radon Handbook**, includes
  - Chapters on
    - Risk assessment, epidemiology
    - Measurement,
    - Mitigation and prevention
    - Cost-effectiveness of prevention/mitigation
    - Risk communication and programme aspects

- Global burden of disease associated with radon exposure

- Critical assessment of approaches to a Radon world map

- Training package and training programs (envisaged)

- Information and Advocacy tools: fact sheets, press memos etc.
WHO International Radon Project


- Working groups
  - Risk assessment (Sarah Darby, Jan Zielinski)
  - Exposure guidelines (David Fenton, Francesco Bochicchio)
  - Cost-effectiveness (Alastair Gray, Terje Strand)
  - Measurement (Bill Field)
  - Mitigation (Bill Angell)
  - Risk communication (James McLaughlin)

- Forum for international scientific and policy exchange

- Develop WHO radon guidelines/publications

- Use WHO communication channels to promote radon awareness
(Global) Burden of Disease Assessment

- Quantification of health effects at population level
  - Numbers of deaths caused by radon exposure
  - Years of healthy life lost due to radon exposure

- GBD provides a global (national, regional) picture of health impacts associated with radon
  - Allows comparison with other risks, e.g. accidents
  - Assists rationale resource allocation

- Tool for monitoring progress of programmes
National Burden of Disease estimates

- Germany:
  - Average radon concentration 49 Bq/m³
  - 37,700 lung cancer deaths annually
  - 5 % (1.7 – 12.6) of all lung cancer deaths attributable to radon

- Switzerland
  - Average radon concentration 78 Bq/m³
  - 8.4% of male lung cancer deaths from radon (8.7% women)

- Higher values estimated in e.g. the USA
Exposure guidelines

- IRP Activity: a survey of WHO Member States, on (inter alia):
  - Radon reference levels in national programmes/guidelines
  - Average radon indoor concentrations
    - Ongoing data collection together with UNSCEAR
    - Important to know for effects of radon programmes at population level
  - Risk communication issues
Radon reference levels in 35 countries

Figure 2a: Radon action (reference) levels in existing buildings (Bq/m³)

WHO IRP:
Reference level
100-400 Bq/m³
WHO-IRP Reference Levels for Radon

- Wide international variation
  - With most countries using levels of 200-400 Bq/m$^3$

- Epidemiological studies do not support the evidence of a "safe" threshold level

- Most lung cancer deaths are associated with a moderate/low concentrations and not with the highest levels

- However, higher concentrations obviously of most concern for an individual home-owner

- Discussions in the WHO IRP support a reference level range of 100-400 Bq/m$^3$
Programme Guidelines: important issues

- How to conduct national radon surveys
  - Trying to get a representative overview of radon in a country, not only from (alleged) high-radon areas

- How to link with anti-smoking programmes
  - Smoking / radon co-action

- Role of building regulations
  - New buildings offer unique chance for radon-proof building
Measurement & Mitigation

• Make use of the extensive experience in some countries to the benefit of all

• Provide an authoritative assessment of measurement and mitigation approaches
  – Overview of techniques used worldwide

• Provide policy options for national authorities that lead to a reduction in exposure to radon
## Typical detectors - survey

<table>
<thead>
<tr>
<th>DETECTOR TYPE (ABBREVIATION)</th>
<th>PASSIVE / ACTIVE</th>
<th>LOWER LIMIT OF DETECTION</th>
<th>TYPICAL UNCERTAINTY</th>
<th>TYPICAL SAMPLING PERIOD</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Charcoal Detector (ACD)</td>
<td>Passive</td>
<td>10 Bq m⁻³</td>
<td>10 – 40 %</td>
<td>1 – 7 days</td>
<td>low</td>
</tr>
<tr>
<td>Alpha-track Detector (ATD)</td>
<td>Passive</td>
<td>$10^4$ Bq h m⁻³</td>
<td>25 %</td>
<td>1 - 12 months</td>
<td>low</td>
</tr>
<tr>
<td>Electret Ion Chamber (EIC)</td>
<td>Passive</td>
<td>$10^3$ Bq h m⁻³</td>
<td>15 %</td>
<td>2 days - 1 year</td>
<td>medium</td>
</tr>
<tr>
<td>Electronic Integrating Device (EID)</td>
<td>Active</td>
<td>20 Bq m⁻³</td>
<td>15 %</td>
<td>2 days - 1 year</td>
<td>medium</td>
</tr>
<tr>
<td>Continuous Radon Monitor (CRM)</td>
<td>Active</td>
<td>5 Bq m⁻³</td>
<td>10 %</td>
<td>2 hours – 1 year</td>
<td>high</td>
</tr>
</tbody>
</table>
## Prevention approaches

### Table 1. Radon Control Options for New Construction

<table>
<thead>
<tr>
<th>Option</th>
<th>Radon Reduction Potential</th>
<th>Long-Term Performance</th>
<th>Monitoring Ease</th>
<th>Quiet and Unobtrusive</th>
<th>Cost to Install</th>
<th>Cost to Operate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealing Soil Contacted Surfaces</td>
<td>None to Low-Moderate</td>
<td>Usually Poor to Fair</td>
<td>Repeated Rn Testing Required</td>
<td>Usually Good</td>
<td>Moderate</td>
<td>Very Low</td>
</tr>
<tr>
<td>Soil Gas Barriers</td>
<td>Highly Variable</td>
<td>Usually Poor to Fair</td>
<td>Repeated Rn Testing Required</td>
<td>Very Good</td>
<td>Moderate to High?</td>
<td>Virtually None</td>
</tr>
<tr>
<td>Passive Ventilation Unoccupied Lower Space</td>
<td>Moderate to Good</td>
<td>Very Good</td>
<td>Repeated Rn Testing Required</td>
<td>Very Good</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Active Ventilation</td>
<td>Very</td>
<td>Very</td>
<td>Repeated Rn Testing Required</td>
<td></td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>
Economic evaluation

- Cost-benefit assessment of different strategies
  - Provide an evidence base for sound decision-making in the prevailing socioeconomic environment

- Comparison with other options to spend money on preventive health issues

- WHO-IRP: specific cost-effectiveness studies for several project member countries
  - Model for other countries
## Model calculations done by IRP

### Table 4.5: Illustrative results from a cost-effectiveness analysis of radon remediation

<table>
<thead>
<tr>
<th>Initial</th>
<th>New homes</th>
<th>Existing homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - never smokers</td>
<td>1.05</td>
<td>1.38</td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - ever smokers</td>
<td>14.31</td>
<td>18.36</td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - all</td>
<td>8.11</td>
<td>10.51</td>
</tr>
</tbody>
</table>

### Post-remediation

<table>
<thead>
<tr>
<th></th>
<th>New homes</th>
<th>Existing homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - never smokers</td>
<td>1.01</td>
<td>1.03</td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - ever smokers</td>
<td>13.80</td>
<td>14.07</td>
</tr>
<tr>
<td>Lifetime cumulative lung cancer risk (%) - all</td>
<td>7.81</td>
<td>7.96</td>
</tr>
</tbody>
</table>

### Health gain per household remediating

<table>
<thead>
<tr>
<th></th>
<th>New homes</th>
<th>Existing homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung cancer cases averted</td>
<td>0.007</td>
<td>0.06</td>
</tr>
<tr>
<td>Total life years gained</td>
<td>0.08</td>
<td>0.67</td>
</tr>
<tr>
<td>Total life years gained – discounted</td>
<td>0.03</td>
<td>0.23</td>
</tr>
<tr>
<td>Average QALYs gained (per lung cancer case averted)</td>
<td>8.99</td>
<td>8.99</td>
</tr>
</tbody>
</table>
Risk communication

- Target groups, approaches, core messages

- Proposed core messages from the Working group

“Radon causes lung cancer”

"Radon is a radioactive gas present in every home”.

“Radon is easy to measure.”

"You can easily protect your family from radon“
IRP Advocacy and Risk Communication

- Fact sheets, press releases, scientific reports etc. to raise public and political awareness about radon and health

- Targeted communication activities
  - What works in radon risk communication?

- Creative ways of raising awareness about radon and extending WHO support to national programs?
  - Especially to countries that are just starting to develop radon programmes
RADON AND CANCER

Radon is a naturally occurring radioactive gas that is odorless, colorless and tasteless. It is produced from radium in the decay chain of uranium. Radon is abundant in nature, particularly in areas with high levels of uranium. Radon gas can be inhaled into the lungs and can cause damage to the DNA and potentially cause lung cancer.

Radon in homes

The concentration of radon in a home depends on many factors. Radon can enter a home through cracks in the foundation, through gaps in basement walls, and through basement windows. Elevated radon levels can be found in homes built on radon-prone soil, and in homes that are located near radon-prone areas.

Radon in drinking water

Radon can also enter a home through contaminated water supplies. Radon can be found in wells, springs, and artesian wells. Radon in drinking water can be a significant source of exposure for individuals in homes with contaminated water supplies.

The International Radon Project (IRP)

WHO initiative to reduce lung cancer risk around the world

Exposure to radon in the home and workplace is one of the main risks of ionizing radiation causing thousands of deaths from lung cancer each year globally. To reduce this burden it is important that national authorities have methods and tools based on solid scientific evidence and sound public health policies. The public needs to be aware of radon risks and the measures to reduce and prevent these.

In 1999 WHO published a report containing several conclusions and recommendations covering the scientific understanding of radon risk and the need for countries to take action in the areas of risk management and risk communication.
Other WHO IRP work: supporting international radiation protection standards, e.g. BSS

- Discusses radon activity/dose conversion factors applied by new reports of UNSCEAR and ICRP

- Proposes use of UNSCEAR conversion factors (which are 50% higher than ICRP factors)

- Maintains ICRP dose reference levels (3-10 mSv/a)
  - Keeping the no-bottom option open depending on further developments with ICRP position on radon issue

- Derived from 3-10 mSv range reference levels:
  - 120 – 400 Bq/m³
  - very close to WHO “proposal”
In 2008

Publication and promotion of:

The WHO Radon handbook

… as a resource for (hopefully many) national radon programmes

WHO thanks all IRP partners for their work!