Indoor Radon
A public health perspective

Dr E. van Deventer

Radiation Programme
Department of Public Health, Environmental and Social Determinants of Health
Geneva, Switzerland
Outline

- Introduction
- Health effects and risks
- Public health aspects
- Outlook
World Health Organization

- **Function**: act as the UN directing and coordinating authority on international health work

- **Objective**: attainment by all peoples of the highest possible level of health

- **Definition**: "HEALTH is a state of COMPLETE physical, mental and social well-being and not merely the ABSENCE of disease or infirmity"  
  *(Constitution, 1948)*
When diplomats met in San Francisco to form the United Nations in 1945, one of the things they discussed was setting up a global health organization. WHO's Constitution came into force on 7 April 1948 — a date we now celebrate every year as World Health Day.

Delegates from 53 of WHO's 55 original member states came to the First World Health Assembly in June 1948. They decided that WHO's top priorities would be the eradication of smallpox, poliomyelitis and leprosy; the control of malaria, typhus, relapsing fever and the prevention of rice blast; and the improvement of the health and nutrition of childhood. These were the ambitious targets set by WHO's first constitution.

1948

1952–1964

Global polio eradication

One of the goals was to bring basic health services to all the world's children. The global polio eradication programme, set up in 1952, had two main objectives: the elimination of polio from the Americas and the eradication of the disease worldwide. By 1960, the Americas had been declared free of wild poliovirus.

1974

International classification of diseases

The International Classification of Diseases (ICD), which dates back to the 1850s and was first known as the International List of Causes of Death, is now used to classify diseases and other health problems and has become the international standard for clinical and epidemiological purposes.

1979

Eradication of smallpox

The eradication of smallpox — a disease which had ravaged the world for centuries — in the late 1970s was one of WHO’s greatest achievements. The campaign to eradicate the deadly disease throughout the world was coordinated by WHO between 1967 and 1979. It was the first and so far the only time that a major infectious disease had been eradicated.

1983

WHO Framework Convention on Tobacco Control

21 May 2003 was an historic day for global public health. After nearly four years of intense negotiations, the World Health Assembly unanimously adopted WHO's first global public health treaty. The treaty is designed to reduce tobacco-related deaths and disease around the world.

2004

A major scientific breakthrough

The Human Immunodeficiency Virus (HIV) is a retrovirus that causes AIDS. The virus was first detected in the 1980s, and by 2003, an estimated 39 million people worldwide were living with HIV/AIDS. The first effective treatment for HIV was developed in the early 1990s, and by 2003, the number of people receiving antiretroviral therapy had increased to more than 4 million. The Global Fund to Fight AIDS, Tuberculosis and Malaria was established in 2001 to provide funding for the treatment and prevention of HIV/AIDS, tuberculosis and malaria.

2005

World Health Assembly revises the International Classification of Diseases

The 1980 revision of the ICD was adopted by the World Health Assembly in 1992. It includes more than 20,000 codes for diseases, injuries and causes of death. The ICD is used by governments, health agencies and researchers around the world to record and analyze health data.
WHO global assessment of the burden of disease from environmental risks (March 2016)
Radiation: an environmental health risk

Science
Risk Assessment

Public Awareness
Risk Communication

Policies
Risk Management
WHO actions on radon

1979: A WHO/EURO working group on indoor air quality first drew attention to the health effects from residential radon exposures

1988: Radon classified as a human carcinogen by IARC

1993: An international WHO workshop on indoor radon considered for the first time a unified approach to control radon exposures and advised on communication of associated health risks

2005: WHO established the *International Radon Project*
  • to identify effective strategies for reducing the health impact of radon
  • to raise awareness about the consequences of long-term radon exposures
Since then...
WHO documents

2009 2010 2011 2012 ...

WHO Housing and health guidelines
Outline

- Introduction
- Health effects and risks
Some history...

- **1556**: Unusually high mortality from respiratory disease among underground metal miners in the Ore mountains.
- **1879**: Disease is lung cancer (75% of all causes of deaths).
- **1913**: Radon is the cause of lung cancer.
- **1950**: Hypothesis that radon progeny cause lung cancer.
- **1960**: First epidemiological studies of miners.
- **1988**: Radon classified as human carcinogen (IARC).
How to assess the risk to health?

1. Hazard identification
   What is the agent and what health problems can it potentially cause?

2. Exposure assessment
   What exposures are likely to occur, and what is the resulting dose to humans?

3. Dose-response relationship
   What are the health problems at different exposure levels?

4. Risk characterization
   What is the health risk in the exposed population?
1- Hazard Identification

From the air to the lungs

Po-218 Pb-214 Bi-214 Po-214

alvéoles 0.1 – 1.0 μm

extra-thoracique 5.5 – 9.2 μm

bronches 3.3 – 5.5 μm

bronchioles 1.0 – 3.3 μm

extra thoracique

bronchi

bronchioles

alveoli

(D’après WB Li, Eurados)

S. Baechler, Bern, Dec. 2014
The major recipient of the dose from inhalation of radon and its decay products is the lung (lung cancer).

99% of the lung dose arises from radon progeny and not from the gas itself, as almost all of the gas that is inhaled is subsequently exhaled.

Only a small proportion of inhaled radon gas reaches the blood and other non-respiratory organs.

Doses to organs other than the respiratory tract are appreciably lower (>100 times).

There is suggestive evidence of an association with other cancers, particular for extra thoracic airways (larynx, pharynx, nose) and leukaemia.
2. Exposure Assessment

Figure XXXVI. Estimated contributions to public exposure from different sources for different countries, and UNSCEAR estimates of worldwide average exposures.
2. Exposure Assessment (cont'd)

Indoor radon distribution
Log normal distribution

- Risk for the overall population exposed to an average radon concentration
- Risk of individuals living with high radon concentration
Residential radon studies

- In the 1980s and 1990s various epidemiological studies on lung cancer risk by residential radon were conducted in Europe, North America and China

- Case-control study design
  - Individual data on residential radon concentrations over the previous 5-35 years
  - Individual data on smoking and other risk factors for lung cancer
Pooled indoor radon studies

- Large size, because the excess risk is expected to be small ⇒ pooling of single studies
  - Europe (Darby et al. 2005; 2006) / 13 studies
    7,148 cases / 14,208 controls
  - North America (Krewski et al. 2005, 2006) / 7 studies
    3,662 cases / 4,966 controls
  - China (Lubin et al. 2004) / 2 studies
    1,050 cases / 1,995 controls
## Results of pooled studies

### Risk of lung cancer according to measured radon concentration

<table>
<thead>
<tr>
<th>Study</th>
<th>ERR/ 100 Bq/m³</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE (Darby et al. 2005)</td>
<td>0.08</td>
<td>0.03 – 0.16</td>
</tr>
<tr>
<td>NORTH AMERICA (Krewski et al. 2005)</td>
<td>0.11</td>
<td>0.00 – 0.28</td>
</tr>
<tr>
<td>CHINA (Lubin et al. 2005)</td>
<td>0.13</td>
<td>0.01 – 0.36</td>
</tr>
</tbody>
</table>

Consistent increase in risk of about 10% in all studies!
3. Dose-response Relationship

Excess Relative Risk
ERR per 100 Bq/m$^3$ = 8.4 %

95% CI = 3% - 16%

Relationship approximately linear without evidence for threshold

[Darby et al. 2005]
### Results on lung cancer risk in uranium miner studies

<table>
<thead>
<tr>
<th>Study</th>
<th>ERR/WLM (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>French / Czech pooled miner cohort (^a) (Tomasek et al, 2008a)</td>
<td></td>
</tr>
<tr>
<td>German miller cohort (Kreuzer et al, 2014)</td>
<td></td>
</tr>
<tr>
<td>French miner sub-cohort 1956+ (Rage et al, 2014)</td>
<td></td>
</tr>
<tr>
<td>European pooled miner case-control study (Hunter et al, 2013)</td>
<td></td>
</tr>
<tr>
<td><strong>German miner sub-cohort 1960+</strong> (Present analysis)</td>
<td></td>
</tr>
<tr>
<td>European pooled residential radon study (Darby et al, 2005)</td>
<td></td>
</tr>
<tr>
<td>BEIR VI joint miner cohort &lt; 100 WLM (NRC, 1999)</td>
<td></td>
</tr>
<tr>
<td>Port Hope uranium processor cohort (Zablotska et al, 2013)</td>
<td></td>
</tr>
</tbody>
</table>

- Studies with low radon exposure rates comparable to current occupational settings
- There is a statistically significant risk of lung cancer after low radon exposures in miners, which is compatible with radon in homes

*Kreuzer et al.*
*Br J Cancer 2015*

\(^a\) centered at 20 years time since exposure and 30 years age at exposure in the Czech/French study
Radon and smoking

- Radon is the second most important cause of lung cancer after smoking in many countries.
- Radon is much more likely to cause lung cancer in people who smoke, or who have smoked in the past, than in lifelong non-smokers.
  - On relative scale (ERR per 100Bq/m³):
    - Radon-associated lung cancer risk is similar among smokers and non-smokers (and ex-smokers).
  - On absolute scale (e.g. numbers of deaths):
    - Majority of radon-associated lung cancers occur among smokers.
4. Risk Characterization

- Scientific evidence suggests 3-14% of lung cancers are due to exposure to indoor radon (2nd cause after smoking)
- Annually **around 100,000 deaths** from lung cancer are due to indoor radon exposure worldwide (Lim et al., 2012)
- Most lung cancer deaths related to radon are associated with low / moderate concentrations in normal dwellings
- Epidemiological studies do not support the evidence of a "safe" threshold level
- WHO recommends a reference level as low as reasonably achievable
WHO Reference Levels

- A RL of **100 Bq/m³** is justified from a public health perspective because an effective reduction of radon-associated health hazards for a population is expected.

- However, if this level cannot be implemented because of country-specific conditions, the reference level should not exceed **300 Bq/m³** (approx. 10mSv / year according to ICRP).

- The decision to set a national RLs needs to account for prevailing economic and societal circumstances and other national factors such as:
  - Distribution of radon in the country
  - Number of existing homes with high radon concentrations
  - Prevalence of smoking
## Reference levels
An evolving approach…

<table>
<thead>
<tr>
<th>Publication</th>
<th>Year</th>
<th>Public</th>
<th>Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO handbook</td>
<td>2009</td>
<td>100-300 Bq/m$^3$</td>
<td>N/A</td>
</tr>
</tbody>
</table>
From concentrations to doses.....

\[ \text{Bq/m}^3 \rightarrow \text{mSv/y} \]
Outline

- Introduction
- Health effects and risks
- Public health aspects
Primary prevention of environmental hazards

- Measures that eliminate or reduce the causes of disease and control exposure to risk

- Primary prevention offers the most cost-effective approach to reducing cancer

- Primary prevention strategies need to be prioritized today because benefit will only be effective in the future due to the long latency of cancer

- Cross-sectoral policies (health, environment, housing, energy) are most effective
At a glance

There were 14.1 million new cancer cases, 8.2 million cancer deaths and 32.6 million people living with cancer (within 5 years of diagnosis) in 2012 worldwide. 57% (8 million) of new cancer cases, 65% (5.3 million) of the cancer deaths and 48% (15.6 million) of the 5-year prevalent cancer cases occurred in the less developed regions.

The overall age standardized cancer incidence rate is almost 25% higher in men than in women, with rates of 205 and 165 per 100,000, respectively. Male incidence rates vary almost five-fold across the different regions of the world, with rates ranging from 79 per 100,000 in Western Africa to 365 per 100,000 in Australia/New Zealand (with high rates of prostate cancer representing a significant driver of the latter). There is less variation in female incidence rates (almost three-fold) with rates ranging from 103 per 100,000 in South-Central Asia to 295 per 100,000 in Northern America.

In terms of mortality, there is less regional variability than for incidence, the rates being 15% higher in more developed than in less developed regions in men, and 8% higher in women. In men, the rates is highest in Central and Eastern Europe (173 per 100,000) and lowest in Western Africa (69). In contrast, the highest rates in women are in Melanesia (119) and Eastern Africa (111), and the lowest in Central America (72) and South-Central (65) Asia.

All Cancers (excluding non-melanoma skin cancer)
Estimated Incidence, Mortality and Prevalence Worldwide in 2012

GLOBOCAN 2012 (IARC)
Lung cancer has been the most common cancer in the world for several decades. There are estimated to be 1.8 million new cases in 2012 (12.9% of the total), 58% of which occurred in the less developed regions. The disease remains as the most common cancer in men worldwide (1.2 million, 16.7% of the total) with the highest estimated age-standardised incidence rates in Central and Eastern Europe (53.5 per 100,000) and Eastern Asia (50.4 per 100,000). Notably low incidence rates are observed in Middle and Western Africa (2.0 and 1.7 per 100,000 respectively). In women, the incidence rates are generally lower and the geographical pattern is a little different, mainly reflecting different historical exposure to tobacco smoking. Thus the highest estimated rates are in Northern America (33.8) and Northern Europe (23.7) with a relatively high rate in Eastern Asia (19.2) and the lowest rates again in Western and Middle Africa (1.1 and 0.8 respectively).

Lung cancer is the most common cause of death from cancer worldwide, estimated to be responsible for nearly one in five (1.59 million deaths, 19.4% of the total). Because of its high fatality (the overall ratio of mortality to incidence is 0.87) and the relative lack of variability in survival in different world regions, the geographical patterns in mortality closely follow those in incidence.
Global Burden of Disease from Radon


### Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Globally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco smoking, including second-hand smoke</td>
<td>2nd</td>
</tr>
<tr>
<td>Residential radon</td>
<td>40th</td>
</tr>
<tr>
<td>Occupational risk factors for injuries</td>
<td></td>
</tr>
<tr>
<td>Occupational low back pain</td>
<td></td>
</tr>
<tr>
<td>Intimate partner violence</td>
<td></td>
</tr>
<tr>
<td>Diet high in fibre</td>
<td></td>
</tr>
<tr>
<td>Diet low in fiber</td>
<td></td>
</tr>
<tr>
<td>Drug use</td>
<td></td>
</tr>
<tr>
<td>Ambitious breast feeding</td>
<td></td>
</tr>
<tr>
<td>Iron deficiency</td>
<td></td>
</tr>
<tr>
<td>Suboptimal breastfeeding</td>
<td></td>
</tr>
<tr>
<td>Childhood overweight</td>
<td></td>
</tr>
<tr>
<td>Ambient particulate matter pollution</td>
<td></td>
</tr>
<tr>
<td>Physical inactivity and low physical activity</td>
<td></td>
</tr>
<tr>
<td>Diet high in sodium</td>
<td></td>
</tr>
<tr>
<td>Diet low in nuts and seeds</td>
<td></td>
</tr>
<tr>
<td>Diet low in vegetables</td>
<td></td>
</tr>
<tr>
<td>Diet low in sea food omega 3 fatty acids</td>
<td></td>
</tr>
<tr>
<td>Drug use</td>
<td></td>
</tr>
<tr>
<td>Occupational risk factors for injuries</td>
<td></td>
</tr>
<tr>
<td>Occupational low back pain</td>
<td></td>
</tr>
<tr>
<td>Intimate partner violence</td>
<td></td>
</tr>
<tr>
<td>Diet high in processed meat</td>
<td></td>
</tr>
<tr>
<td>Diet low in fibre</td>
<td></td>
</tr>
<tr>
<td>Diet low in fibre</td>
<td></td>
</tr>
<tr>
<td>Unproven sanitation</td>
<td></td>
</tr>
<tr>
<td>Lead exposure</td>
<td></td>
</tr>
<tr>
<td>Diet high in polyunsaturated fatty acids</td>
<td></td>
</tr>
<tr>
<td>Diet high in trans fatty acids</td>
<td></td>
</tr>
<tr>
<td>Vitamin A deficiency</td>
<td></td>
</tr>
<tr>
<td>Optimal vitamin A deficiencies</td>
<td></td>
</tr>
<tr>
<td>Dietary vitamin A deficiencies</td>
<td></td>
</tr>
<tr>
<td>Zinc deficiency</td>
<td></td>
</tr>
<tr>
<td>Diet high in sugar beverages</td>
<td></td>
</tr>
<tr>
<td>Childhood milk above</td>
<td></td>
</tr>
<tr>
<td>Unproven source</td>
<td></td>
</tr>
<tr>
<td>Low bone mineral density</td>
<td></td>
</tr>
<tr>
<td>Occupational risk factors for injuries</td>
<td></td>
</tr>
<tr>
<td>Occupational carotenoids</td>
<td></td>
</tr>
<tr>
<td>Occupational cancer</td>
<td></td>
</tr>
<tr>
<td>Diet low in calcium</td>
<td></td>
</tr>
<tr>
<td>Ambient ozone pollution</td>
<td></td>
</tr>
<tr>
<td>Residential radon</td>
<td></td>
</tr>
<tr>
<td>Diet low in milk</td>
<td></td>
</tr>
<tr>
<td>Occupational asthma</td>
<td></td>
</tr>
<tr>
<td>Diet high in red meat</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 5: Risk factors ranked by attributable burden of disease, 2010*
Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013

<table>
<thead>
<tr>
<th>All risk factors</th>
<th>1990 deaths (in thousands)</th>
<th>2013 deaths (in thousands)</th>
<th>Median percent change deaths</th>
<th>1990 DALYs (in thousands)</th>
<th>2013 DALYs (in thousands)</th>
<th>Median percent change DALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental risks</td>
<td>25 085 (24 385 to 25 821)</td>
<td>30 839 (29 719 to 31 949)</td>
<td>23.0% (19.0 to 27.3)</td>
<td>1035 987 (980 813 to 1 092 478)</td>
<td>996 554 (927 157 to 1 072 340)</td>
<td>-3.8% (-7.7 to -0.1)</td>
</tr>
<tr>
<td>Air pollution</td>
<td>8492 (8036 to 8953)</td>
<td>8181 (7651 to 8726)</td>
<td>-3.7% (-9.6 to 2.4)</td>
<td>400 345 (374 489 to 424 432)</td>
<td>289 517 (265 778 to 312 094)</td>
<td>-27.7% (-32.1 to -23.2)</td>
</tr>
<tr>
<td>Ambient particulate matter pollution</td>
<td>4 808 (4 459 to 5 157)</td>
<td>5 527 (5 109 to 5 944)</td>
<td>14.8% (5.8 to 25.3)</td>
<td>157 831 (145 269 to 171 007)</td>
<td>141 456 (130 071 to 153 652)</td>
<td>-10.5% (-17.4 to -2.8)</td>
</tr>
<tr>
<td>Household air pollution from solid fuels</td>
<td>2 857 (2 482 to 3 216)</td>
<td>2 893 (2 463 to 3 303)</td>
<td>1.3% (-1.4 to 18.8)</td>
<td>68 120 (64 972 to 71 405)</td>
<td>69 673 (65 585 to 73 552)</td>
<td>2.3% (-3.4 to 8.2)</td>
</tr>
<tr>
<td>Ambient ozone pollution</td>
<td>133 (105 to 162)</td>
<td>217 (161 to 272)</td>
<td>63.8% (14.5 to 125.1)</td>
<td>3 038 (2 296 to 3 814)</td>
<td>5 073 (3 576 to 6 620)</td>
<td>66.9% (12.2 to 137.1)</td>
</tr>
<tr>
<td>Other environmental risks</td>
<td>731 (523 to 965)</td>
<td>945 (663 to 1 279)</td>
<td>29.2% (17.1 to 40.5)</td>
<td>17 015 (12 567 to 22 173)</td>
<td>18 822 (13 300 to 25 407)</td>
<td>10.5% (0.4 to 20.1)</td>
</tr>
<tr>
<td>Residential radon</td>
<td>63 (41 to 86)</td>
<td>92 (61 to 128)</td>
<td>46.3% (13.1 to 87.9)</td>
<td>1 503 (984 to 2 086)</td>
<td>1 979 (1 331 to 2 768)</td>
<td>31.7% (2.4 to 67.6)</td>
</tr>
<tr>
<td>Lead exposure</td>
<td>668 (465 to 899)</td>
<td>853 (572 to 1 181)</td>
<td>27.6% (15.1 to 39.1)</td>
<td>15 512 (10 967 to 20 727)</td>
<td>16 843 (11 494 to 23 505)</td>
<td>8.5% (-2.4 to 18.3)</td>
</tr>
</tbody>
</table>
WHO Radon Handbook (2009)

Introduction

1. Health Effects of Radon
2. Radon Measurements
3. Prevention and Mitigation
4. Cost-Effectiveness
5. Radon Risk Communication
6. National Radon Programmes
2. Radon measurements

- Radon measurements in homes are easy to perform, but need to be based on standardized (e.g. national) protocols to ensure accurate and consistent measurements.

- Long-term integrated radon measurements are preferred for assessing the annual average radon concentration within a house or other dwelling.

- High temporal variation of indoor radon makes short-term measurements unreliable for most applications.

- The type of detector should be carefully selected since it influences the cost of measurement per dwelling and therefore the cost of a radon programme on a national level.

- Quality assurance and quality control measures are strongly recommended to assure the reliability of radon measurements.
3. Radon prevention and mitigation

- Strategies both for radon prevention (new dwellings) and mitigation (existing dwellings) are needed to achieve an overall risk reduction.

- Radon sources, radon concentrations and radon transport mechanisms influence the choice of prevention and mitigation strategies.

- Radon measurements should always be made to determine the effectiveness of any radon prevention or mitigation effort.

- Professionals in the building sector are key players for radon prevention and mitigation. Strategies are needed to train them and to ensure their competence in this area.

- Research-based guidelines and/or standards for radon prevention and mitigation should be established at national level.
4. Cost-effectiveness of radon control

- The cost-effectiveness of preventive measures improves as the average radon concentration in an area increases. However, in many cases it would be cost-effective to install radon prevention measures such as a radon barrier in all new buildings.

- The cost-effectiveness of remediating existing buildings is strongly influenced by the costs of identifying affected homes and by the remediation costs themselves.

- Even if cost-effectiveness analyses indicate that remediation programmes are not cost-efficient on a nationwide basis, in areas of high radon concentration remediation should still be undertaken.

- Cost-effectiveness analyses are helpful tools for evaluating current policies and can lead to new and more cost-effective ways of reducing radon risk.

- Cost-effectiveness analyses provide useful information for policy makers when evaluating policies and alternatives, but are subject to uncertainties and limitations. The results of such analyses should therefore be interpreted and communicated carefully.
# Environmental and Occupational Interventions for Primary Prevention of Cancer: A Cross-Sectorial Policy Framework

*Carolina Espina, Miquel Porta, Joachim Schüz, Ildefonso Hernández Aguado, Robert V. Percival, Carlos Dora, Terry Slevin, Julietta Rodriguez Guzman, Tim Meredith, Philip J. Landrigan, and Maria Neira*

## Table 1. Summary of nine environmental and occupational risk factors for cancer: areas to be strengthened.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Scientific evidence in support of causation</th>
<th>Awareness-raising measures</th>
<th>Existence of policies/recommendations</th>
<th>Existence of legislation</th>
<th>Level of advocacy for primary prevention</th>
<th>Implementation of policies and legislation</th>
<th>Public perception of risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td>POPs</td>
<td>Intermediate</td>
<td>Low</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Indoor radon</td>
<td>High</td>
<td>Intermediate</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Outdoor air pollution/diesel exhaust</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Indoor emissions from household combustion</td>
<td>Intermediate</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Secondhand smoke</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Ionizing radiation (medical exposure)</td>
<td>High</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>UV and tanning beds</td>
<td>High</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Electromagnetic fields</td>
<td>Low</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

POPs, persistent organic pollutants. The methodology followed to classify the risk factors combined a review of relevant literature, consultation with scientists and public health experts, and consensus reached among participants in the WHO International Conference on “Environmental and Occupational Determinants of Cancer. Interventions for Primary Prevention” (17–18 March 2011, Asturias, Spain) (WHO 2011).

*Amount of scientific evidence in support of causation. Number of awareness-raising measures (e.g., campaigns) at national and/or international level. Extent of governmental or nongovernmental policies, understood as principles or rules, and/or recommendations at the national and/or international level. Existence of legislation at national and/or international level. Level of advocacy (governmental and nongovernmental) for primary prevention of cancer at national and/or international level. Level of implementation of policies and/or legislation at national and/or international level. Level of the perception of risk held by the general population versus the actual amount of scientific evidence in support of causation.
<table>
<thead>
<tr>
<th>Scientific evidence in support of causation(^a)</th>
<th>Awareness-raising measures(^b)</th>
<th>Existence of policies/recommendations(^c)</th>
<th>Existence of legislation(^d)</th>
<th>Level of advocacy for primary prevention(^e)</th>
<th>Implementation of policies and legislation(^f)</th>
<th>Public perception of risk(^g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Intermediate</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

\(\text{a.}\) Amount of scientific evidence in support of causation.

\(\text{b.}\) Number of awareness-raising measures (e.g., campaigns) at national and/or international level.

\(\text{c.}\) Extent of governmental or nongovernmental policies, understood as principles or rules, and/or recommendations at the national and/or international level.

\(\text{d.}\) Existence of legislation at national and/or international level.

\(\text{e.}\) Level of advocacy (governmental and nongovernmental) for primary prevention of cancer at national and/or international level.

\(\text{f.}\) Level of implementation of policies and/or legislation at national and/or international level.

\(\text{g.}\) Level of the perception of risk held by the general population versus the actual amount of scientific evidence in support of causation.
5. Radon risk communication

- The communication of radon risk and prevention messages poses serious challenges because radon is not widely known and may not be perceived as a health risk by the public.

- In addition to informing the public, a primary objective of radon risk communication is to persuade policy makers that radon is an important public health issue that requires action.

- Effective risk communication requires co-operation between organizations, clear and coordinated messages, and the enlistment of collaborators with good community credibility.

- As part of radon risk communication, the development of a set of core messages aimed at target audiences is recommended. These messages should be simple, brief, and to the point.

- An assessment of perceptions and the level of knowledge regarding radon in the target audiences is strongly recommended. This should be done both before and after a risk communication campaign.
## Radon Risk If You Smoke

<table>
<thead>
<tr>
<th>Radon Level</th>
<th>If 1,000 people who smoked were exposed to this level over a lifetime*...</th>
<th>The risk of cancer from radon exposure compares to**...</th>
</tr>
</thead>
<tbody>
<tr>
<td>740 Bq/m³</td>
<td>About 260 people could get lung cancer</td>
<td>250 times the risk of drowning</td>
</tr>
<tr>
<td>370 Bq/m³</td>
<td>About 150 people could get lung cancer</td>
<td>200 times the risk of dying in a home fire</td>
</tr>
<tr>
<td>296 Bq/m³</td>
<td>About 120 people could get lung cancer</td>
<td>30 times the risk of dying in a fall</td>
</tr>
<tr>
<td>148 Bq/m³</td>
<td>About 62 people could get lung cancer</td>
<td>5 times the risk of dying in a car crash</td>
</tr>
<tr>
<td>74 Bq/m³</td>
<td>About 32 people could get lung cancer</td>
<td>6 times the risk of dying from poison</td>
</tr>
<tr>
<td>48.1 Bq/m³</td>
<td>About 20 people could get lung cancer</td>
<td>(Average indoor radon level)</td>
</tr>
<tr>
<td>14.8 Bq/m³</td>
<td>About 3 people could get lung cancer</td>
<td>(Average outdoor radon level)</td>
</tr>
</tbody>
</table>

## Radon Risk If You've Never Smoked

<table>
<thead>
<tr>
<th>Radon Level</th>
<th>If 1,000 people who never smoked were exposed to this level over a lifetime*...</th>
<th>The risk of cancer from radon exposure compares to**...</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 Bq/m³</td>
<td>About 36 people could get lung cancer</td>
<td>35 times the risk of drowning</td>
</tr>
<tr>
<td>100 Bq/m³</td>
<td>About 18 people could get lung cancer</td>
<td>20 times the risk of dying in a home fire</td>
</tr>
<tr>
<td></td>
<td>About 15 people could get lung cancer</td>
<td>4 times the risk of dying in a fall</td>
</tr>
<tr>
<td></td>
<td>About 7 people could get lung cancer</td>
<td>The risk of dying in a car crash</td>
</tr>
<tr>
<td></td>
<td>About 4 person could get lung cancer</td>
<td>The risk of dying from poison</td>
</tr>
<tr>
<td></td>
<td>About 2 people could get lung cancer</td>
<td>(Average indoor radon level)</td>
</tr>
<tr>
<td></td>
<td>(Average outdoor radon level)</td>
<td></td>
</tr>
</tbody>
</table>

[http://www.epa.gov/radon/healthrisks.html](http://www.epa.gov/radon/healthrisks.html)
Communication for local authorities

Featured

BASIC RADON FACTS

The U.S. Surgeon General recommends ALL homes be tested for radon. Radon is a naturally occurring radioactive gas that can come from any building next to the soil, in the soil, inside homes, or with or without a basement. Radon gas is invisible, radioactive, and can cause lung cancer. Radon gas is a leading cause of lung cancer in the U.S. if you test your home, you can reduce your risk of lung cancer by 90%.

Kansas State University, under a cooperative agreement with EPA, provides radon training programs in France. The most common type of radon test kit is a passive sampler, which provides a single exposure. For more information about radon testing, call 1-800-368-5202 or visit envirofacts.epa.gov/radon.

You can fix a radon problem.

There is a solution to fix a radon problem. You can call your state radon program for help in finding qualified radon inspectors in your area. Your local community will also benefit by radon inspectors in the area. To reduce radon levels, you must reduce radon levels in your home. Fixing a radon problem reduces the risk of lung cancer for people who live in the radon-contaminated home.

New homes can be built with radon-resistant features.

Building new homes with safe and effective radon-resistant features can reduce radon entry. To learn more, contact your builder or visit www.epa.gov/radon.

How to Get Radon Test Kits

To get an easy-to-use radon test kit, you can:
1. Buy a test kit at your local hardware store.
2. Contact your state radon program.

New homes can be built with radon-resistant features.

Building new homes with safe and effective radon-resistant features can reduce radon entry. To learn more, contact your builder or visit www.epa.gov/radon.

Every home should be tested before or soon after you move in. Even homes built with radon-resistant construction features should be tested. If high radon levels are found, it is easier and costs less to reduce radon levels in homes that are built radon-resistant.

Download this recently revised customizable fact sheet!

(PDF, 2 pp, 150 K) EPA 402/F-12/005, February 2013

Hojas de datos sobre el radón (PDF) (2 pp, 178 K) EPA 402/F-12/005, May 2013

World Health Organization

IAEA/WHO/NNR Works

South Africa | 7 May 2016
Webinars

“Radon, Smoking, and Lung Cancer – Tracking States Collaborate to Improve Visualization and Outreach.”

US CDC, 15 May 2014

http://chronicdisease.site-ym.com/members/group_content_view.asp?group=128552&id=385881
Communication with the public

January is NATIONAL RADON ACTION MONTH

Le radon

Radon in Homes
What is it?
What harm can it do?
What can be done about it?

Radiological Protection Institute of Ireland
An Institiúidh Físiciteach as an Chumhacht Ráidelitych
Infographics

Movies

http://www.radon.gv.at/dms/radon/dateien/radoncd0/index.html


http://www.bfs.de/media/radon/Radon.swf
Opportunities

- Energy conservation vs. radon control
- Public and political awareness on radon exposures
- Training and education of professionals
- Radon within the context of indoor air quality
- Implementation of new International Basic Safety Standards
Thank You for Your Attention

Join our radon email list!!
radon@listserv.who.int

Radiation Programme  
World Health Organization  
Avenue Appia, 20  
Geneva, Switzerland  
www.who.int/ionizing_radiation