Radon Health Risk Science

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Radon – Overview

- Lung cancer
- Biological risks
- Miner –based studies
- Residential radon studies
- Occupational exposure
- Global activities
RISK PERCEPTION: Why is the evidence ignored or not accepted??

- Invisible, odorless, colorless
- Naturally occurring *outdoors*
- Can not link an individual death to radon exposure
- Long latency period
- Not a dread hazard
- Cancers occur one at a time
- Lung cancer does not occur in children
- Voluntary risk
- Lack of press – no sensational story
- No sensory reminders to repetitively stimulate us to think about it
"Statistics are people with the tears wiped away."

Irving Selikoff
### Ten Leading Cancer Types for the Estimated New Cancer Cases and Deaths by Sex, 2010

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated New Cases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td>217,730</td>
<td>28%</td>
</tr>
<tr>
<td>Lung &amp; bronchus</td>
<td>116,750</td>
<td>15%</td>
</tr>
<tr>
<td>Colon &amp; rectum</td>
<td>72,090</td>
<td>9%</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>52,760</td>
<td>7%</td>
</tr>
<tr>
<td>Melanoma of the skin</td>
<td>38,870</td>
<td>5%</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>35,380</td>
<td>4%</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td>35,370</td>
<td>4%</td>
</tr>
<tr>
<td>Oral cavity &amp; pharynx</td>
<td>25,420</td>
<td>3%</td>
</tr>
<tr>
<td>Leukemia</td>
<td>24,690</td>
<td>3%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>21,370</td>
<td>3%</td>
</tr>
<tr>
<td><strong>All Sites</strong></td>
<td><strong>789,620</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
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<tr>
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<tr>
<td><strong>Estimated Deaths</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung &amp; bronchus</td>
<td>86,220</td>
<td>29%</td>
</tr>
<tr>
<td>Prostate</td>
<td>32,050</td>
<td>11%</td>
</tr>
<tr>
<td>Colon &amp; rectum</td>
<td>26,580</td>
<td>9%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>18,770</td>
<td>6%</td>
</tr>
<tr>
<td>Liver &amp; intrahepatic bile duct</td>
<td>12,720</td>
<td>4%</td>
</tr>
<tr>
<td>Leukemia</td>
<td>12,660</td>
<td>4%</td>
</tr>
<tr>
<td>Esophagus</td>
<td>11,650</td>
<td>4%</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>10,710</td>
<td>4%</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>10,410</td>
<td>3%</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td>8,210</td>
<td>3%</td>
</tr>
<tr>
<td><strong>All Sites</strong></td>
<td><strong>299,200</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

FIGURE 4 Annual Age-Adjusted Cancer Death Rates Among Males for Selected Cancers, United States, 1930 to 2006

FIGURE 5 Annual Age-Adjusted Cancer Death Rates* Among Females for Selected Cancers, United States, 1930 to 2006


Copyright ©2010 American Cancer Society
<table>
<thead>
<tr>
<th>CANCER TYPE</th>
<th>ESTIMATED U.S. DEATHS/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lung and Bronchus</td>
<td>157,300</td>
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<td>8,700</td>
</tr>
</tbody>
</table>

Tobacco Use and Cancer

Some Cancer-Causing Chemicals in Tobacco Smoke

- aminostilbene
- arsenic
- benz[a]anthracene
- benz[a]pyrene
- benzene
- benzo[b]fluoranthene
- benzo[c]phenanthrene
- benzo[f]fluoranthene
- cadmium
- chrysene
- dibenz[a c]anthracene
- dibenzo[a e]fluoranthene
- dibenz[a h]acridine
- dibenz[a j]acridine
- dibenzo[c g]carbazone
- N-dibutylnitrosamine
- 2,3-dimethylchrysene
- indeno[1,2,3-c d]pyrene
- S-methylchrysene
- S-methylfluoranthene
- alpha-naphthylamine
- nickel compounds
- N-nitrosodimethylamine
- N-nitrosomethylethylamine
- N-nitrosodiethylamine
- N-nitrosonornicotine
- N-nitrosoanabasine
- N-nitrosoanabasine
- N-nitrosopiperidine
- polonium-210
Radioactivity of tobacco trichomes and insoluble cigarette smoke particles. Martell EA
Radon Decay Products

Radon-222 → \( ^\alpha,^\gamma \) → Polonium-218 → \( ^\alpha,^\gamma \) → Lead-214 → \( ^\beta,^\gamma \) → Bismuth-214 → \( ^\beta,^\gamma \) → Polonium-214 → \( ^\alpha,^\gamma \) → Lead-210 → \( ^\beta,^\gamma \) → Bismuth-210 → \( ^\beta,^\gamma \) → Polonium-210 → \( ^\alpha,^\gamma \) → Lead-206 → Stable

Radon-222: 4 day
Polonium-218: 3 min
Lead-214: 27 min
Bismuth-214: 20 min
Polonium-214: 0.2 ms
Lead-210: 22 yrs
Bismuth-210: 5 day
Polonium-210: 138 day
Lead-206: Stable
U.S. Radon Potential

- Based on geology and surveys
- Expected closed building radon (pCi/L):
  - Zone 1: 4.0 and above
  - Zone 2: between 2.0 & 4.0
  - Zone 3: 2.0 and lower
What is some of the scientific evidence that radon is a health risk?

- Biological credibility (plausibility)
- Validity of study design
- Consistency across investigations
- Appropriateness of temporal relationship
- Evidence of dose-response relationship
Alpha Decay

Radon - 222 → $^4$He + $^{218}$Po

$^4$He nucleus ejected from $^{222}$Rn nucleus
Radon Decay Products

Po-218 and Po-214 deliver the majority of radiation dose to the lung.
What Happens When Radon-222 Enters a House?

- Radon enters home.
- Radon radioactively decays into Radon Decay Products (RDPs) in the air.
- Some RDPs remain in the air.
- Some RDPs plate out on surfaces.
Why are radon decay products a health concern?

These particles are easily inhaled and deposited in the lungs where they can damage sensitive lung tissue.
What Happens When Radon Decay Products Are Inhaled?

- Highly radioactive particles adhere to lung tissue, where they can irradiate sensitive cells.
- Radiation can alter the cells, increasing the potential for cancer.

*Double Strand Breaks*
Ionizing radiation can directly and indirectly damage DNA

Defects in tumor suppressor genes – p53

At risk individuals – GSTM1
(glutathione S-transferase M1)
Annual Effective Dose Equivalent to Member of the U.S. Population
NCRP 93 (1987)

Natural (mrem)
Radon 200
Cosmic 27
Terrestrial:
-external 28
-internal 39
Artificial (mrem)
-Diag. X-rays 39
-Nuc. Med. 14
-Consumer Pro. 10
-Other ~1
TOTAL ~360

Radon 55%
Natural 82%
Cosmic 27%
Terrestrial:
-external 28%
-internal 39%
Internal (Inside Human Body) 11%
Medical X-rays 11%
Nuclear Medicine 3%
Consumer Products < 1%
Other includes:
Occupational 0.3%
Fallout < 0.3%
Nuclear Power 0.1%
Miscellaneous 0.1%

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Artificial 18%
Cosmic 27%
Terrestrial:
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Terrestrial:
-external 28
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Artificial (mrem)
-Diag. X-rays 39
-Nuc. Med. 14
-Consumer Pro. 10
-Other ~1
TOTAL ~360
Studies of Underground Miners
Cohort Studies (15) of Radon-Exposed Miners

- Port Radium
- Ontario
- Beaverlodge
- Newfoundland
- Cornwall
- Sweden
- France
- E. Germany
- Czech Republic (2)
- China
- New Mexico
- Colorado
- Brazil
- Radium Hill
### National Academy of Sciences
BEIR VI (1999): Pooled Analysis of 11 Miner Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Lung ca</th>
<th>P-yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>China *</td>
<td>980</td>
<td>175,342</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>705</td>
<td>106,924</td>
</tr>
<tr>
<td>Colorado *</td>
<td>336</td>
<td>87,821</td>
</tr>
<tr>
<td>Ontario</td>
<td>291</td>
<td>380,719</td>
</tr>
<tr>
<td>Newfoundland *</td>
<td>118</td>
<td>48,742</td>
</tr>
<tr>
<td>Sweden *</td>
<td>79</td>
<td>33,293</td>
</tr>
<tr>
<td>New Mexico *</td>
<td>69</td>
<td>55,964</td>
</tr>
<tr>
<td>Beaverlodge</td>
<td>65</td>
<td>118,385</td>
</tr>
<tr>
<td>Port Radium</td>
<td>57</td>
<td>52,677</td>
</tr>
<tr>
<td>Radium Hill *</td>
<td>54</td>
<td>51,624</td>
</tr>
<tr>
<td>France</td>
<td>45</td>
<td>43,962</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,787</strong></td>
<td><strong>1,155,453</strong></td>
</tr>
</tbody>
</table>

Mean: WLM = 164, Duration=5.7 y

*Lubin et al. 1995

* With smoking info
Radon Exposure of Lung Cancer Cases in Miners

Number of lung cancer cases

Working Level Months

Reside 25Y @

<20 pCi/L
<10 pCi/L
<5 pCi/L

<table>
<thead>
<tr>
<th>Working Level Months</th>
<th>Number of Lung Cancer Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>110</td>
</tr>
<tr>
<td>25-49</td>
<td>226</td>
</tr>
<tr>
<td>50-99</td>
<td>129</td>
</tr>
<tr>
<td>100-199</td>
<td>222</td>
</tr>
<tr>
<td>200-399</td>
<td>438</td>
</tr>
<tr>
<td>400-799</td>
<td>567</td>
</tr>
<tr>
<td>800+</td>
<td>602</td>
</tr>
<tr>
<td>1000+</td>
<td>493</td>
</tr>
</tbody>
</table>
Dose-Response in Miner Studies (I)

Lubin et al. 1995
NRC BEIR VI, 1999
Dose-Response in Miner Studies (II)

Newfoundland

New Mexico

Sweden

Beaverlodge

Relative risk vs. Cumulative WLM
Dose-Response in Miner Studies (III)

Graph showing relative risk vs. cumulative WLM for Port Radium, Radium Hill, and France.
Risk estimates based primarily on radon-exposed miners

Estimated 18,600 lung cancer deaths each year in the U.S. from residential radon exposure
In 2003, the EPA updated the BEIR VI risk estimates to 21,000 radon-related lung cancer deaths each year in the United States.

http://www.epa.gov/radon/risk_assessment.html

Based on its analysis, EPA estimates that out of a total of 146,400 lung cancer deaths nationally in 1995, 21,100 (14.4%) were radon related. Although it is not feasible to totally eliminate radon from the air, it is estimated that about one-third of the radon-related lung cancers could be averted by reducing radon concentrations in homes that exceed EPA’s recommended 4 picocurie per liter (pCi/L) action level (NAS 1999).
AR for Radon

~ 1/3 of lung cancers from homes above EPA action level (or 5-8K lung cancer deaths/yr)
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<tr>
<td><strong>6. Leukemia</strong></td>
<td>21,840</td>
</tr>
<tr>
<td><strong>&gt;&gt; Radon- Induced Lung Cancer</strong></td>
<td>21,000</td>
</tr>
<tr>
<td><strong>7. Non-Hodgkin Lymphoma</strong></td>
<td>20,210</td>
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Epidemiologic Residential Radon Studies
Why are residential radon studies important?

- Validation for miner-based extrapolations
  - differences in mine/home air environments
  - differences in subjects’ inhalation patterns
  - differences in other exposures
- Evaluate other factors, e.g., females
- Demonstrate lung cancer risks directly
Dose Response Model
Linear Non-Threshold Theory

Dose

Adverse Health Effects

Observed Effects

Radon-Exposed Miners
Studies of Residential Radon and Lung Cancer

- Currently 22 (+) indoor radon studies
- Limitations for individual studies
  - Historical exposure assessment
  - Most did not link radon concentrations to time spent in home
  - Sample size issues
Residential Radon Case-Control Around the World

European Studies

13 Studies from 9 Countries
- Austria
- Czech Republic
- Finland [nationwide]
- Finland [south]
- France
- Germany [eastern]
- Germany [western]
- Italy
- Spain
- Sweden [nationwide]
- Sweden [never smokers]
- Sweden [Stockholm]
- United Kingdom

Total 7,148 cases and 14,208 controls

North American Studies

7 Studies from 2 countries:
- New Jersey
- Winnipeg
- Missouri I [non-smoking women]
- Missouri II [women]
- Iowa
- Connecticut
- Utah-South Idaho

Total 3,622 cases and 4,966 controls
Residential Radon Studies

Odds Ratios at 4.0 pCi/L (150 Bq/m³)

China: Lubin 2004
Eur: Darby et al. 2004, 2006
NA: Krewski et al. 2005, 2006
Pooled Residential Radon Studies

  - Enhance Rn measurement protocol comparability
  - Continuing meetings of PIs after 1995
- Pooling results published 2004-2006
  - North America (7)
  - Europe (13)
  - China (2)
- World pooling (2011?)
Pooled Analyses Agreement at 3 pCi/L ??

New Jersey, Missouri I, Canada, Iowa, Missouri II, a combined study from Connecticut, Utah and S. Idaho

Shenyang, China, Stockholm, Sweden, Swedish nationwide, Winnipeg, Canada, S. Finland, Finnish nationwide, SW England, W. Germany, Sweden, Czech Republic, Italy-Trento, Spain, Austria, France, China - Gansu Province, E. Germany
Results of All Radon Studies of Lung Cancer
Have Previous Residential Radon Studies Underestimated Risk?
Why have the risks been under reported in residential radon studies?

**Exposure Assessment Uncertainty**

- Missing radon measurements in previous homes
- Failure to link radon concentrations with where people spent time
- QA/QC issues
- Studies performed in low radon areas
- Inadequate consideration of temporal radon variations
- High percentage of proxy respondents
## Basement and Living Area Radon Concentrations for U.S. Residential Radon Studies

<table>
<thead>
<tr>
<th>Study Location</th>
<th>Geometric Mean in pCi/L</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basement</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>New Jersey</td>
<td></td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Missouri-I</td>
<td>2.4</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Missouri-II</td>
<td>2.4</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Iowa</td>
<td>4.6</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Connecticut, Utah</td>
<td>1.5</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Southern Idaho$^2$</td>
<td>1.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

$^1$Summary data represent those homes that were measured with no imputed (values added to replace missing values) values.
Risk estimates decrease when one fails to link radon concentrations with where the subject spends time.

Random misclassification of radon exposure tends to bias studies toward finding no association between radon concentrations and lung cancer.
Support for this research was provided by a grant from the National Institute of Environmental Health Sciences, National Institutes of Health.

Continuing support was provided by the National Cancer Institute and U.S. EPA.
IRLCS Inclusion Criteria

20-year residency criteria in current home avoids imputation of data

Some studies imputed 20% - 58% of data because of the inability to measure radon in previous homes
Risk Estimates for Alternative Models

(all subjects)

Exposure Percentile Categories

20-39% 40-59% 60-79% 80+%
Risk Estimates for Alternative Models

(live cases and controls)

Odds Ratio

20-39% 40-59% 60-79% 80+%}

Complete exposure

Other location radon concentrations only

Occupational Radon Exposure—also a health risk
Occupational Exposure to Radon – Very Common

- Mine workers, including uranium, hard rock, and vanadium
- Workers remediating radioactive contaminated sites, including uranium mill sites and mill tailings
- Workers at underground nuclear waste repositories
- Radon mitigation contractors and testers
- Employees of natural caves
- Phosphate fertilizer plant workers
- Oil refinery workers
- Utility tunnel workers
• Subway tunnel workers
• Construction excavators
• Power plant workers, including geothermal power and coal
• Employees of radon health mines
• Employees of radon balneotherapy spas (waterborne radon source)
• Water plant operators (waterborne radon source)
• Fish hatchery attendants (waterborne radon source)
• Employees who come in contact with technologically enhanced sources of naturally occurring radioactive materials
• Incidental exposure in almost any occupation from local geologic radon sources
• Farming related activities
Other types of cancer may be associated with protracted radon exposure
Iowa radon leukaemia study: A hierarchical population risk model for spatially correlated exposure measured with error

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³Departments of Occupational and Environmental Health and Epidemiology, The University of Iowa, Iowa City, IA, U.S.A.

SUMMARY

This paper presents a Bayesian model that allows for the joint prediction of county-average radon levels and estimation of the associated leukaemia risk. The methods are motivated by radon data from an epidemiologic study of residential radon in Iowa that include 2726 outdoor and indoor measurements. Prediction of county-average radon is based on a geostatistical model for the radon data which assumes an underlying continuous spatial process. In the radon model, we account for uncertainties due to incomplete spatial coverage, spatial variability, characteristic differences between homes, and detector measurement error. The predicted radon averages are, in turn, included as a covariate in Poisson models for incident cases of acute lymphocytic (ALL), acute myelogenous (AML), chronic lymphocytic (CLL), and chronic myelogenous (CML) leukaemias reported to the Iowa cancer registry from 1973 to 2002. Since radon and leukaemia risk are modelled simultaneously in our approach, the resulting risk estimates accurately reflect uncertainties in the predicted radon exposure covariate. Posterior mean (95 per cent Bayesian credible interval) estimates of the relative risk associated with a 1 pCi/L increase in radon for ALL, AML, CLL, and CML are 0.91 (0.78–1.03), 1.01 (0.92–1.12), 1.06 (0.96–1.16), and 1.12 (0.98–1.27), respectively. Copyright © 2007 John Wiley & Sons, Ltd.
Summary

- Radon is a global public health concern.
- The residential radon studies have provided direct evidence that prolonged residential radon is one of our leading public health risks and major cause of cancer mortality.
- Radon is our leading environmental cause of cancer mortality in the United States and seventh leading cause of cancer mortality overall.
Global Perspective on Radon


5.5 Evaluation

There is sufficient evidence for the carcinogenicity of radon and its decay products in experimental animals.

There is sufficient evidence for the carcinogenicity of radon and its decay products in humans.

Overall evaluation

Radon and its decay products are carcinogenic to humans (Group 1).
Background

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

1988: Radon was classified as a human carcinogen by IARC, the WHO specialized cancer research agency.

1993: An international workshop on indoor radon, organized by WHO, involving scientists and radon experts from Europe, North America and Asia 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 and to raise awareness about the consequences of long term radon exposures.
WHO-IRP Objectives

• Identify effective strategies for reducing the health impact of radon
• Promote sound policy options as well as prevention and mitigation programmes
• Raise public, political and economical awareness about the consequences of exposure to radon
• Estimate the global health impact of exposure to residential radon using available data on radon worldwide
"Recent findings from case-control studies on lung cancer and exposure to radon in homes completed in many countries allow for substantial improvement in risk estimates and for further consolidation of knowledge by pooling data from these studies."

"The consistency of the findings from the latest pooled analyses of case-control studies from Europe and North America as well as China provides a strong argument for an international initiative to reduce indoor radon risks."
Why is WHO involved in Radon?

**Radon is a Public Health issue!**

- Scientific evidence suggests 6-15% of lung cancers are due to exposure to indoor radon (2nd after smoking)
  - Globally > 70,000 cases (up to 170,000 cases) annually
  - Direct evidence from case-control studies on indoor radon
- Bringing together WHO Member States for joint international approach
  - To reduce radon health burden
  - To raise awareness among the public and policy makers
WHO-IRP National Partners

- Albania
- Argentina
- Austria
- Belgium
- Brasil
- Bulgaria
- Canada
- China
- Czech Republic
- Finland
- France
- Georgia
- Germany
- Greece
- Hungary
- India
- Ireland
- Italy
- Japan
- Lithuania
- Luxembourg
- Norway
- Poland
- Romania
- Russian Federation
- Serbia
- Slovenia
- South Korea
- Spain
- Sweden
- Switzerland
- Turkey
- USA
- Ukraine
- United Kingdom
WHO-IRP Deliverables

- Information and advocacy tools: fact sheets, press memos etc.  

- Radon survey  

- Handbook on indoor radon  

- Report on global burden of disease associated with radon exposure  

- A radon world map  

- Training package and training programs  

(✓): Completed

(planned): In progress
WHO HANDBOOK ON INDOOR RADON
A PUBLIC HEALTH PERSPECTIVE
Chapters

- Health Effects of Radon
- Radon Measurements
- Prevention and Mitigation
- Cost-Effectiveness
- Radon Risk Communication
- National Radon Programs
THE WHO INITIATIVE TO REDUCE LUNG CANCER RISK AROUND THE WORLD
6. National radon programmes

- National radon programmes should aim to reduce the overall population risk and the individual risk for people living with high radon concentrations.

- To limit the risk to individuals, a national reference level of 100 Bq/m$^3$ is recommended. Wherever this is not possible, the chosen level should not exceed 300 Bq/m$^3$.

- To reduce the risk to the overall population, building codes should be implemented that require radon prevention measures in homes under construction. Radon measurements are needed because building codes alone cannot guarantee that radon concentrations will be below the reference level.

- Detailed national guidance on radon measurement protocols is essential to ensure quality and consistency in radon testing. A national radon database that monitors the measurement results over time can be used to evaluate the effectiveness of a national radon programme.

- An effective national radon programme requires input from several agencies within a country. One agency should lead the implementation and coordination and ensure linkage with tobacco control and other health promotion programmes.
Availability of WHO Handbook

• **WHO Handbook on Indoor Radon: A Public Health Perspective:**
  

• **WHO Radon Webpage:**
  
REDUCING ENVIRONMENTAL CANCER RISK

What We Can Do Now
This report is submitted to the President of the United States in fulfillment of the obligations of the President’s Cancer Panel to appraise the National Cancer Program as established in accordance with the National Cancer Act of 1971 (P.L. 92-218), the Health Research Extension Act of 1987 (P.L. 99-158), the National Institutes of Health Revitalization Act of 1993 (P.L. 103-43), and Title V, Part A, Public Health Service Act (42 U.S.C. 281 et seq.).
Comparative risk assessments by EPA [Environmental Protection Agency] and its Science Advisory Board... have consistently ranked radon among the top four environmental risks to the public.

SUSAN CONRATH
U.S. ENVIRONMENTAL PROTECTION AGENCY

We have to go beyond a voluntary program [for radon mitigation] at this point. You can see all these homes in the future will need retrofitting and it’s going to be three times, four times more expensive than doing it when we first build the homes.

WILLIAM FIELD
UNIVERSITY OF IOWA
The cancer risk attributable to residential radon exposure has been clearly demonstrated and must be better addressed. The following are needed:

- The Environmental Protection Agency (EPA) should consider lowering its current action level (4 pCi/L) for radon exposure, taking into account data on radon-related cancer risk developed since the existing action level was established.

- Public and health care provider education should be developed and broadly disseminated to raise awareness of radon-related cancer risk.

EPA

HHS
Health care provider professional organizations
Media
Improved testing methods for residential radon exposure and better methods for assessing cumulative exposure should be developed. Tax deductions or other incentives should be implemented to encourage radon mitigation retrofitting of existing housing. Building code changes should be made to require radon reduction venting in new construction.

All schools, day care centers, and workplaces should be tested at regular intervals for radon. Radon level data must be made available to the public. Buildings found to have levels in excess of the EPA action level should be mitigated.
Richard D. Williams, M.D., Rubin H. Flocks Professor and former Head of the University of Iowa Department of Urology, died on May 28, 2010 at age 65 following a brave fight against cancer.

Dr. Williams was born on October 7, 1944 in Wichita, Kansas, where he met and married the love of his life, Beverly Ferguson. Dr. Williams received his B.S. degree from Abilene Christian University in 1966 and his M.D. from Kansas University School of Medicine in 1970. He completed his Urology Residency at the University of Minnesota in 1976, after which he received research training as a National Kidney Foundation/American Urological Association fellow. Dr. Williams was selected Chief of Urology at the San Francisco Veterans Affairs Medical Center in 1979, and became Assistant Professor and Chief of Urologic Oncology at University of California San Francisco in 1983. Subsequently he served as the Rubin H. Flocks Professor and head of the University of Iowa, Department of Urology from 1984 until he stepped down earlier this year due to his declining health. His commitment to research aimed at improving patient care was central to his long and distinguished career.
Please feel free to contact me with questions.

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