EPA's Application of Radon Risk Models: Past, Present and Future

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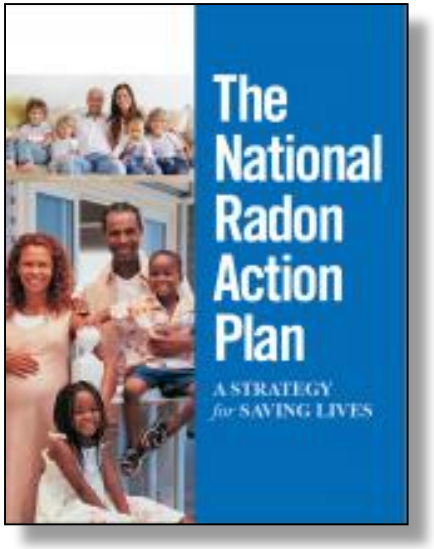
5th NAS Beebe Symposium · October 20, 2021

EPA's National Radon Program

- **Purpose: Maximize annual number of mitigations and homes built with radon-resistant features.**
- **Support states and tribes through grants (SIRG) and technical assistance**
- **Team with federal, non-profit, industry & state partners on the National Radon Action Plan**
- **Participate in the development of private sector standards of practice**
- **Work with real estate and home builders to promote health protection and reduce liability**
- **Oversee/support quality credentialing of radon measurement and the mitigation industry**
- **Provide NIST-traceable radon reference for radon industry**



Radon – Results

- **Over 5M homes with active radon mitigation systems or built to be radon-resistant; nearly 2,000 lives saved/year**
  - ***Action Level of 4 pCi/L (148 Bq/m^3)***
- **Newly adopted building codes requiring radon resistant or active new construction**
- **New requirement for radon testing and mitigation for HUD's Multifamily Housing Insurance Programs**
- **<u>More to be done</u>: about 7 million homes with high radon levels; all homes need to be tested**

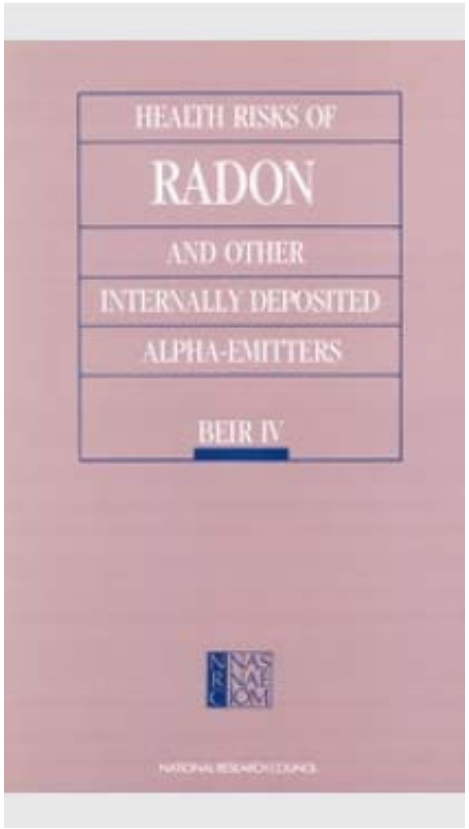
February 2021

EPA Risk Models for Radon vs. Other Radionuclides

- Other radionuclides
  - Most cancers: LSS of atomic bomb survivors
  - Models: Dose to risk
- Radon
  - Adaptations of NAS models (e.g., BEIR IV, VI, Radon in DW)
    - EPA a main or sole sponsor of NAS reports
  - Source: Pooled analysis of underground miner cohorts
  - "Validated": results from residential case-control studies
  - Models: Exposure (e.g., WLM) to risk
  - Use (example): to set EPA action level

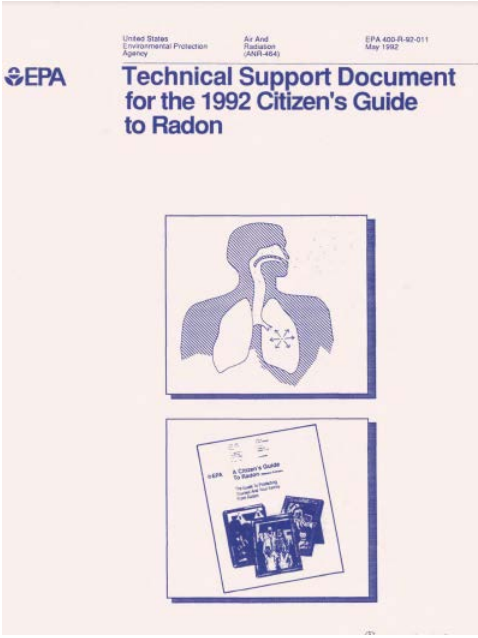
BEIR IV (1988)

- Pooled analysis of 4 cohorts of miners
- Some evidence of an inverse dose rate effect (Colorado cohort) – not in final model
- ERR (final) model
  - Attained age > 64: Decreases 3-fold
  - Time-since-exposure: 5-14 y vs. 15+y
- Multiplicative radon/smoking interaction
- Assumed dose per unit exposure to target cells is the same for occupational vs. environmental exposures
- Lifetime risk projections based on 1980-84 U.S. mortality data
- About 8-9% of U.S. lung cancer deaths attributable to radon



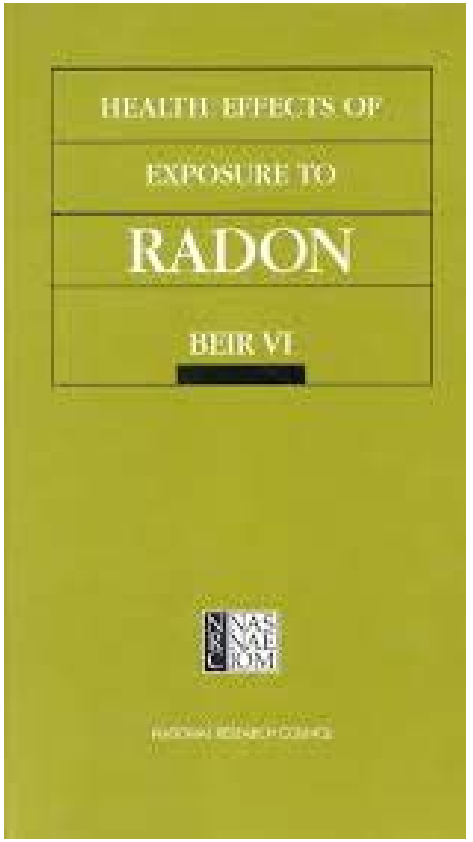
A Basis for EPA Radon Program Recommendations (1992)

- EPA Technical Support Document compared costs/benefits: alternative action levels & testing strategies
  - Adjusted BEIR IV model (e.g., K = 0.7)
  - National survey data on radon levels
    - Avg. = 1.25 pCi/L; 0.24 WLM per year
  - Data on size of measurement errors
  - Cost/effectiveness of mitigation
- Screening/confirmatory measurements
- Avg. cost per life saved = $1.4 M (2021 $)
- 13.6 K lung cancer deaths per year



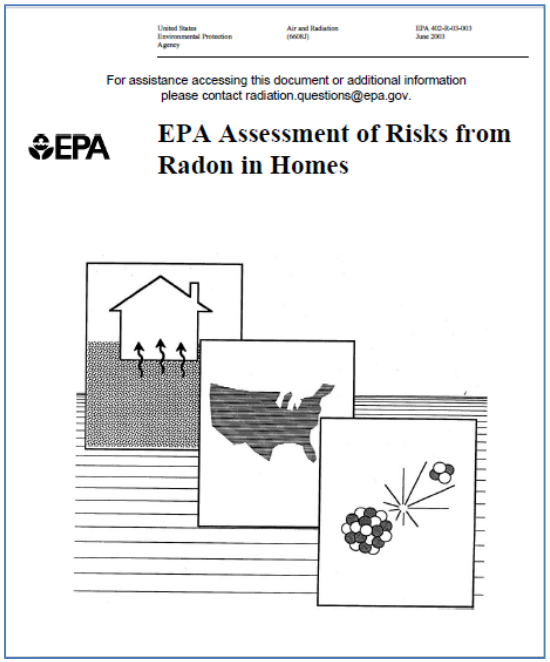
BEIR VI (1999)

- Pooled analysis of 11 cohorts of miners
- Inverse dose rate effect (2 different models)
- ERR depends on attained age, TSE
  - Finer categorization than in BEIR IV
- Sub-multiplicative radon/smoking interaction
- Dose per unit exposure to target cells is the same for occupational vs. environmental exposures
- About 15K or 21K (about 10 or 14% of) lung cancer deaths in U.S. attributable to radon
  - Among NS, percentage is about double.



EPA Assessment of Risks from Radon in Homes (2003)

- Applied scaled version of BEIR VI age-concentration risk model
- More detailed smoking prevalence and updated mortality data than in BEIR VI
- Provided numerical estimates of risk per unit exposure
  - General pop.: 5.4×10^{-4} WLM^{-1}
  - Never smokers: 1.7×10^{-4} WLM^{-1}
- 21K lung cancer deaths per year


United States Environmental Protection Agency | Air and Radiation (6602J) | EPA 402-R-03-003 June 2003

For assistance accessing this document or additional information please contact radiation.questions@epa.gov.

EPA

EPA Assessment of Risks from Radon in Homes

“LNT” (Interpolation/Extrapolation) Issue(s)

- ***Exposure***
- Lifetime Exposure in Homes
  - Action level = 14 WLM
- Avg. Underground Miner Exposure (BEIR 6)
  - 164 WLM
  - (< 50 WLM): 14.8 WLM

- Exposure ***Rate***
- Action level: 0.016 WL
- Avg. for Underground Miners: 2.9 WL
  - 0.4 WL (Sweden)
  - > 10 WL (Colorado, Port Radium)
- Mean duration: 5.7 y

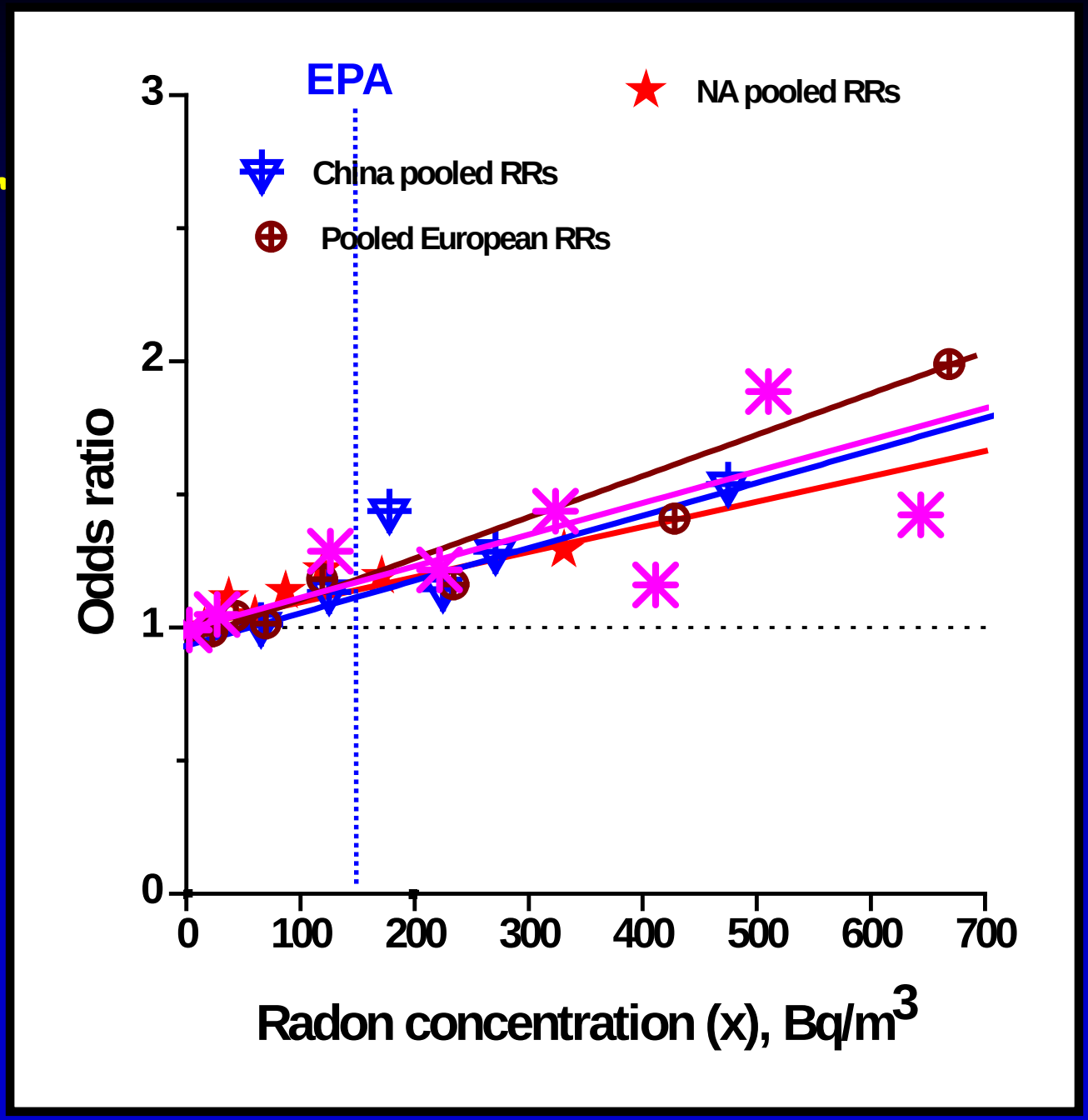
Cohen's Ecological Study

- Cohen: inverse relationship between county-level radon levels and lung cancer mortality
- BEIR VI: review of ecological study limitations
- Puskin (2003)
  - Negative correlation between radon & other smoking-related cancers point to negative correlation between smoking & radon levels.
  - Mossman (HP Newsletter Editorial): "The Debate is Over"

Pooled Analyses of Residential Case-control Studies

- Three distinct analyses:
  - China (Lubin et al.), Europe (Darby et al.), North America (Krewski et al.)
- WHO Handbook (2008) risks based on European pooled analyses
- Limited information on radon levels
- Remarkable agreement with results from miner studies (next slide courtesy of Jay Lubin)

Comparability of Results of Indoor Radon Studies of Lung Cancer



Comparative Dosimetry of BEIR VI

James, Birchall, Akabani (2004)

- To resolve BEIR VI "K-factor" controversy
- K-factor is the ratio:

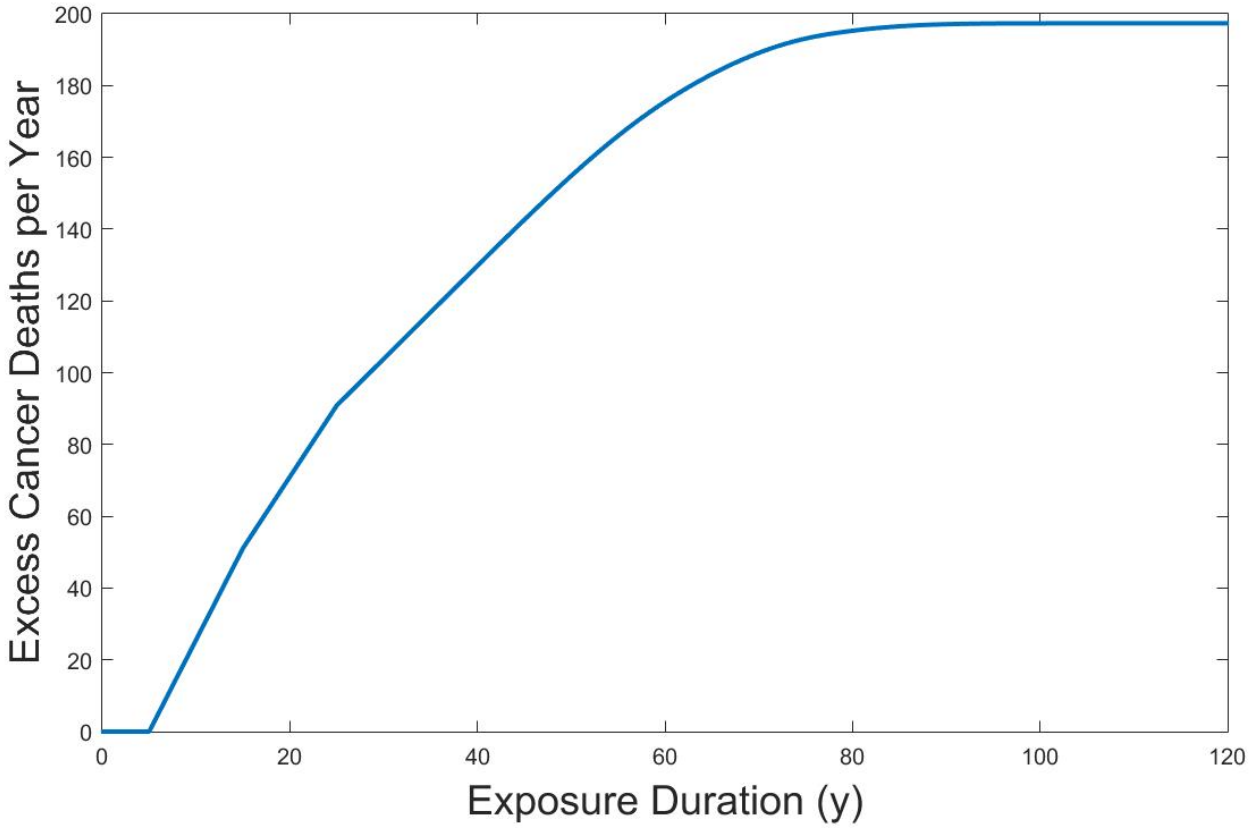
  (Risk per WLM in homes) ÷ (Risk per WLM in mines)

- K-factor of 1 is "clearly appropriate"
- K depends primarily on α activity weighted particle size distributions in homes & mines
  - Data on mines from 1970s – all w/ diesel eq.
  - Data from only 6 homes in NE U.S. and Canada

Update of Cost/Benefit Calculations?

- EPA is doing a sensitivity analysis to determine the effect “new information” might have on cost/benefit calculations for the NRP.
- Lung cancers avoided would otherwise occur 5 to >100 years after radon levels are reduced
- Recommendation to discount benefits (at 3%).
- Decisions on discounting have a huge impact on benefit/cost results.

Excess Lung Cancer Deaths
(per million in homes at 3.3 pCi/L)



Summary and Additional Questions

- Compared to residential studies, underground miner studies allow for more precise estimates, including of temporal/age trends
  - Improved risk models from PUMA
  - BUT how do miner and in-home risks compare (*e.g.*, K-factor)?
  - What about radon risks for females, childhood exposures?
- Should future projections be primarily based on risk models from
  - Underground miner studies? With validation from residential studies?
  - OR based primarily on Residential case-control studies?
  - OR on data and/or results from BOTH types of studies?
- How best to model risks for hotspots (e.g., in PA)?