Risk Assessment and Risk Communication

Radiation Epidemiology Course

National Cancer Institute

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Attributable Risk

The Surgeon General estimates 440,000 smoking attributable deaths in 2000.

What does this mean?

WHO COUNTS??

How Would You Explain?

- **A future risk of cancer for CT evaluation of CF patients estimated as 0.02% for males with median survival to age 36 years?**
- **An increase in risk for radiation caused cancer of 410 per 0.1 Gy?**
- **A lifetime increase in risk of cancer of 1%?**

From Knowledge to Policy: The Five-Step Method

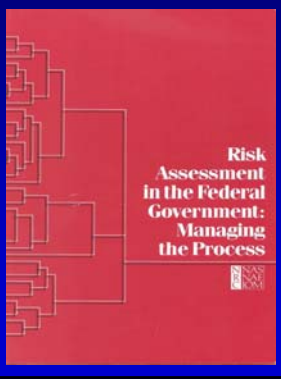
1. **Is _____ a carcinogen?**
2. **How risky is _____?**
3. **How are people exposed to _____?**
4. **How can exposure to _____ be prevented?**
5. **How will the policy be evaluated?**

Informing Decisions About Risk

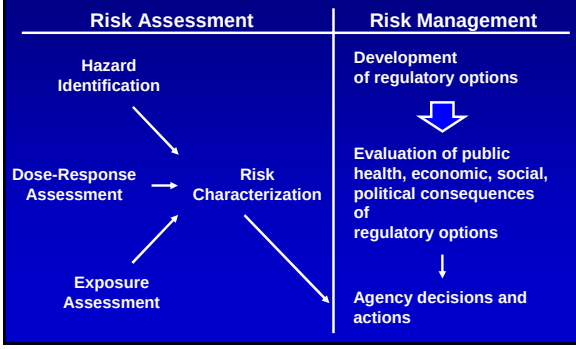
•Risk assessment does not provide answers, but is an essential component of informed decisions about risks.

•Risk assessment is a useful way for organizing what is known and not known for the purpose of risk communication

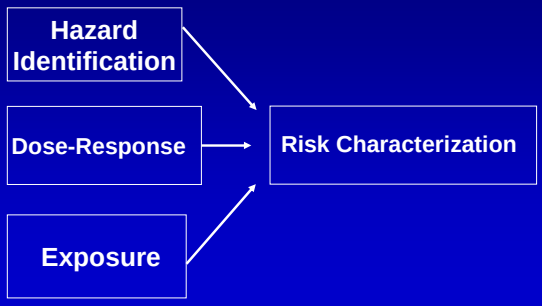
The "Red Book"



Elements Of Risk Assessment And Risk Management



The Four Components of QRA



Four Steps of Risk Assessment

- Hazard Identification
- Dose Response
- Exposure Assessment
- Risk Characterization

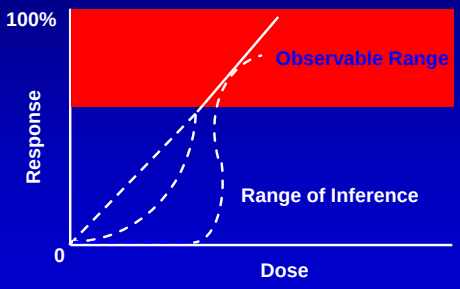
Component 1: Hazard Identification

Hazard Identification

- Review and analyze toxicity data
- Weigh the evidence that a substance causes various toxic effects
- Evaluate whether toxic effects in one setting will occur in other settings

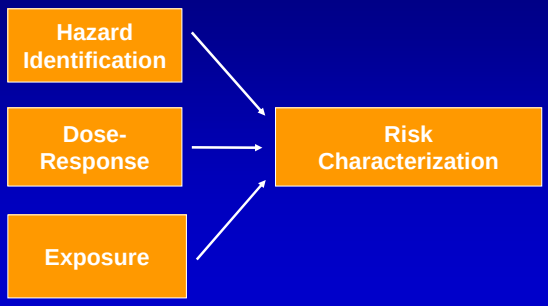
Component 2: Dose-Response Assessment

Dose-Response Curve



Component 3: Exposure Assessment

Component 4: Risk Characterization



Risk Characterization

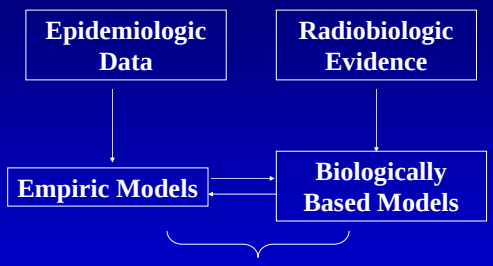
- Integrate and summarize the hazard identification, dose-response assessment, and exposure assessment
- Develop public health risk estimates
- Develop a framework to define the significance of the risk
- Present assumptions, uncertainties, scientific judgments

Uncertainty: Always A Problem

"Uncertainty can be defined as a lack of precise knowledge as to what the truth is, whether qualitative or quantitative." (NAS, 1994)

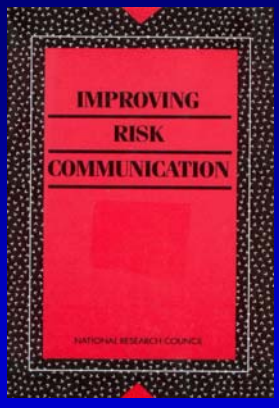
"To know one's ignorance is the best part of knowledge." (The Tao, No. 71).

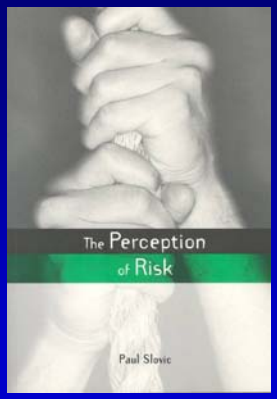
Characterizing Radiation Risks



Issues in Radiation Risk Communication

- What are the element of the risk characterization?
- What is the level of certainty?
- What is the level of risk for individuals?
- With what certainty can risk be predicted?
- What is the level of risk for populations?
- With what certainty can risk be estimated?





Risk Communication

"Risk communication is an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management."

National Research Council. 1989.Improving Risk Communication. Washington, D.C.: National Academy Press.

Source: http://www.riskworld.com/

Source: http://www.atsdr.cdc.gov/HEC/primer.html

Twenty Years of Risk Communication
Progress or Process?

- *First Stage*
  All we have to do is get the number right
- *Second Stage*
  All we have to do is tell them the numbers
- *Third Stage*
  All we have to do is explain what we mean by the numbers
- *Fourth Stage*
  All we have to do is show them they've accepted similar risks in the past

Source: Fischhoff B. Risk Anal. 1995 Apr;15(2):137-45.

Twenty Years of Risk Communication
Progress or Process?

- *Fifth Stage*
  All we have to do is show them it's a good deal for them
- *Sixth Stage*
  All we have to do is treat them nice
- *Seventh Stage*
  All we have to do is make them partners

Source: Fischhoff B. Risk Anal. 1995 Apr;15(2):137-45.

Dimensions of Risk and Their Effects on Risk Perception

Dimension	Conditions Associated with Higher Perceived Risk	Conditions Associated with Lower Perceived Risk
Severity of Consequences	Large numbers of fatalities or injuries per event	Small numbers of fatalities or injuries per event
Probability of Occurrence	High probability of occurrence	Low probability of occurrence
Catastrophic Potential	Fatalities or injuries grouped in time and space	Fatalities or injuries distributed randomly in time and space
Reversibility	Irreversible	Consequences appear reversible
Latency of Effects	Chronic effects that are delayed in time	Acute effects immediately realized

Adapted from Cohrssen JJ and Covello VT. 1989. Risk Analysis: A Guide to Principles and Methods for Analyzing Health and Environmental Risks. US Council on Environmental Quality.

Dimensions of Risk and Their Effects on Risk Perception

Dimension	Conditions Associated with Higher Perceived Risk	Conditions Associated with Lower Perceived Risk
Impact on Future Generations	Risks borne equally or greater by future generations	Risks borne primarily by current generation
Victim Identity	Identifiable victim	Statistical victims
Familiarity	Unfamiliar risks	Familiar risks
Understanding	Lack of personal understanding of mechanisms or processes involved	Personal understanding of mechanisms or processes involved

Adapted from Cohrssen JJ and Covello VT. 1989. Risk Analysis: A Guide to Principles and Methods for Analyzing Health and Environmental Risks. US Council on Environmental Quality.

Dimensions of Risk and Their Effect on Risk Perception

Dimension	Conditions Associated with Higher Perceived Risk	Conditions Associated with Lower Perceived Risk
Scientific Uncertainty	Risks unclear to scientists	Risks relatively well-known to scientists
Dread	Risks evoke fear, terror, or anxiety	Risks not dreaded
Voluntariness	Involuntary exposures	Risks taken at one's own choice
Controllability	Little personal control over risk	Some personal control over risk
Clarity of Benefits	Benefits from activity generating risk questioned	Clear benefits

Adapted from Cohrssen JJ and Covello VT. 1989. Risk Analysis: A Guide to Principles and Methods for Analyzing Health and Environmental Risks. US Council on Environmental Quality.

Dimensions of Risk and Their Effects on Risk Perception

Dimension	Conditions Associated with Higher Perceived Risk	Conditions Associated with Lower Perceived Risk
Equity	No direct benefit for those at risk from an activity	Seemingly equitable distribution of risks and benefits
Institutional Trust	Lack of trust in institutions responsible for risk management	Responsible institutions well- trusted
Personal Stake	Individual personally at risk	Individual not personally at risk
Attribution of Blame	Risk caused by human failure	Risk caused by nature
Media Attention	Much media attention	Little media attention

Adapted from Cohrssen JJ and Covello VT. 1989. Risk Analysis: A Guide to Principles and Methods for Analyzing Health and Environmental Risks. US Council on Environmental Quality.

RISK = HAZARD PLUS OUTRAGE

What About Radiation Risks?

Severity:	small → large
Probability:	low → high
Catastrophe:	possible
Reversible:	no
Latency:	short/long
Uncertainty:	little

What About Radiation Risks?

Benefits:	yes (understood??)
Controllable:	yes and no
Familiarity:	some
Impact on future:	seen as "yes"

Successful Risk Communication

Messages about expert knowledge are necessary to the risk communication process; they are not sufficient, however, for a message to be successful.

National Research Council. 1989. Improving Risk Communication. Washington, D.C.: National Academy Press.

Good Risk Communication

Good risk communication may not always improve a situation. However, poor risk communication will almost always make a situation worse.

National Research Council. 1989.Improving Risk Communication. Washington, D.C.: National Academy Press.

Successful Risk Communication

- Does not always lead to better decisions
- Need not result in consensus or uniform behavior

National Research Council. 1989. Improving Risk Communication. Washington, D.C.: National Academy Press.

Risk Messages vs. Risk Communication

Risk Messages include
- one-way messages
- verbal statements
- pictures
- advertisements
- publications
- legal briefs
- warning signs
- other declaratory activities

Risk Communication includes
- two-way messages
- dialogue
- announcements/warnings
- reactions
- perceptions
- personal beliefs

Successful Risk Communication

Raises the level of understanding and satisfies those involved that they are adequately informed within the limits of available knowledge.

National Research Council. 1989. Improving Risk Communication. Washington, D.C.: National Academy Press.

Comparisons in Risk Communication

- When lay and expert values differ, reducing different kinds of hazard to a common metric (such as number of fatalities per year) and presenting comparisons only on that metric have great potential to produce misunderstanding and conflict and to engender mistrust of expertise

National Research Council. 1989.Improving Risk Communication. Washington, D.C.: National Academy Press.

Comparative Risk

- Use other, familiar risks to place new risk in a context
- Comparisons often made to known risks—motor vehicle accidents, airplane travel
- Comparison may be artificial—e.g., voluntary vs. involuntary risk
- Comparison may trivialize the new risk

7 Cardinal Rules

- Rule 1 - Accept and involve the public as a legitimate partner
- Rule 2 - Plan carefully and evaluate performance
- Rule 3 - Listen to your audience
- Rule 4 - Be honest, frank, and open
- Rule 5 - Coordinate and collaborate with other credible sources
- Rule 6 - Meet the needs of the media
- Rule 7 - Speak clearly and with compassion

The Seven Realities of Risk Communications

- Involuntary risks are unacceptable
- Once minds are made up, it's hard to change them
- Trust and credibility require long-term effort
- Unfamiliarity breeds contempt
- Health risks may be secondary in environmental controversy
- Community values/beliefs/ perceptions can outweigh science in shaping public policy
- The best communication can't reverse bad risk management decisions

FIGURE 2.2 SOURCE: Drawing by Richter; ©1988 The New Yorker Magazine, Inc.

Some Confusing Terms

- Uncertainty
- Error
- Sensitivity
- Variability
- Risk
- Probability

Communicating Uncertainty

- Statistical descriptors
  - Confidence intervals
- Quantitative characterization
  - Distribution-based approaches
- Qualitative description
  - Adjectival characterization
  - Weight of evidence

How And When Do Scientists Communicate Radiation Risks?

- In reporting findings of individual studies
- In communicating findings of risk assessments
- As experts: consultants, advocates, testifying, public resource
- As policy-makers and risk communicators

Table 16.1 *Summary of Perception and Acceptance of Risks from Diverse Sources of Radiation Exposure*

	Perceived risk	
	Technical experts	*Public*
Nuclear power/ nuclear waste	Moderate risk Acceptable	Extreme risk Unacceptable
X-rays	Low/moderate risk Acceptable	Very low risk Acceptable
Radon	Moderate risk Needs action	Very low risk Apathy
Nuclear weapons	Moderate to extreme risk Tolerance	Extreme risk Tolerance
Food irradiation	Low risk Acceptable	Moderate to high risk Acceptability questioned
Electric and magnetic fields	Low risk Acceptable	Significant concerns developing Acceptability questioned

Source: Slovic, The Perception of Risk , Earthscan 2000

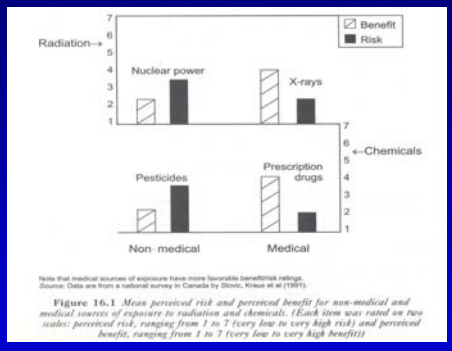
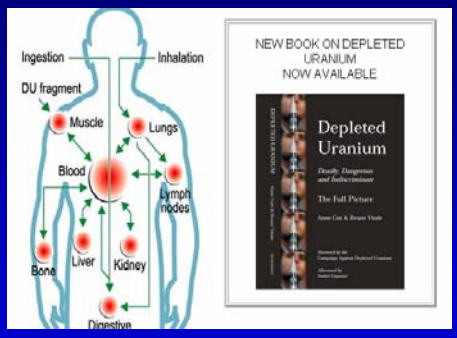


Figure 16.1 *Mean perceived risk and perceived benefit for non-medical and medical sources of exposure to radiation and chemicals. (Each item was rated on two scales: perceived risk, ranging from 1 to 7 (very low to very high risk) and perceived benefit, ranging from 1 to 7 (very low to very high benefit))*

Source: Slovic, The Perception of Risk , Earthscan 2000



Source: http://www.miltoxproj.org/DU/dupd.htm

Depleted Uranium Penetrators: IOM Conclusions

- ***Lung cancer:*** **The committee concludes that there is limited/suggestive evidence of no association between exposure to uranium and lung cancer at cumulative internal dose levels lower than 200 mSv or 25 cGy. However, there is inadequate/insufficient evidence to determine whether an association does or does not exist between exposure to uranium and lung cancer at higher levels of cumulative exposure.**

Source: Institute of Medicine. Gulf War and Health: Vo. 1. Depleted Uranium, Pyridostigmine Bromide, Sarin, and Vaccines. 2001

Depleted Uranium Penetrators: IOM Conclusions, continued

- ***Renal function*****: The committee concludes that there is limited/suggestive evidence of no association between exposure to uranium and clinically significant renal dysfunction.**
- ***Other health outcomes*****: The committee concludes that there is inadequate/insufficient evidence to determine whether an association does or does not exist between exposure to uranium and the following health outcomes: lymphatic cancer; bone cancer; nervous system disease; nonmalignant respiratory disease; or other health outcomes….**

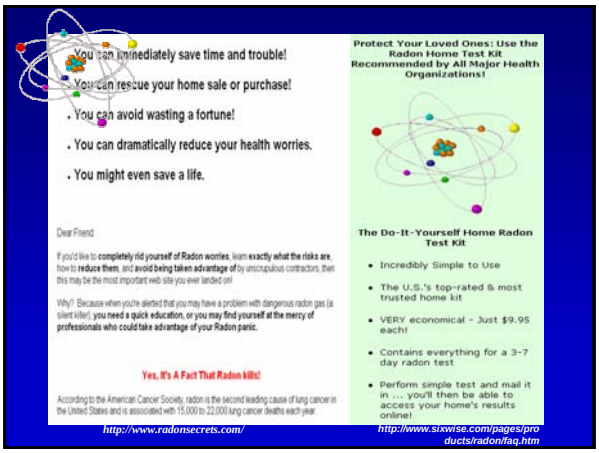
Source: Institute of Medicine. Gulf War and Health: Vo. 1. Depleted Uranium, Pyridostigmine Bromide, Sarin, and Vaccines. 2001

Players in Radiation Risk Assessment and Communication

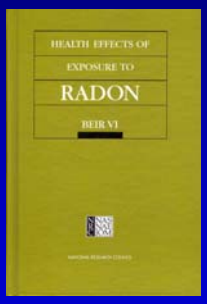
Organizations	ICRP NCRP NAS/NRC UN
Committees	UNSCEAR BEIR NCRP ICRP
Agencies	EPA NRC FDA DOE

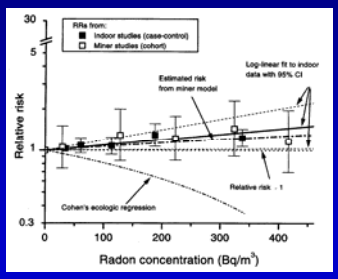
Radon and Lung Cancer Indoor Radon: Colorless, Odorless Killer?

- **Radon ubiquitous indoors**
- **Concentrations log normal**
- **Some homes have levels as high as miners**
- **Majority of time spent at home**



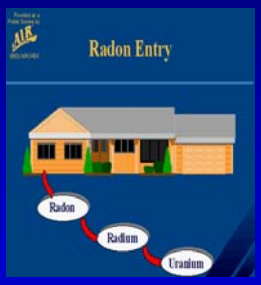
BEIR VI: Assessing Radon's Risks





4 Components of Risk Assessment

- **Hazard Identification**
- **Dose Response**
- **Exposure Assessment**
- **Risk Characterization**

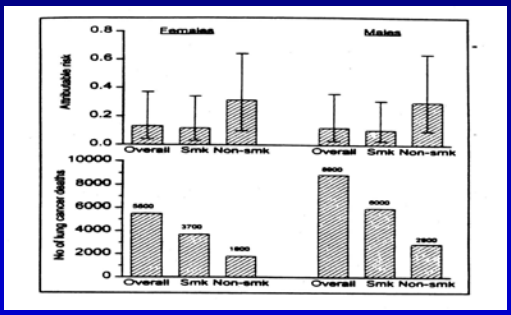


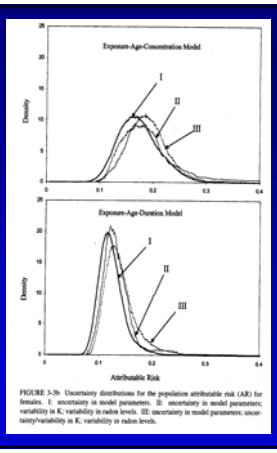
Radon Risk Characterization

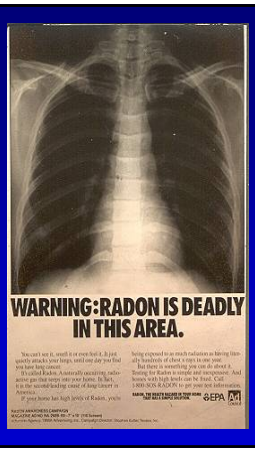
		Attributable to Rn progeny exposure	
	Lung Cancer Deaths	Number[a]	Number[b]
Males			
Total	65,100	7,800	8,900
Smokers	55,300	6,600	6,000
Never-Smokers	9,800	1,200	2,900
Females			
Total	39,200	4,700	5,500
Smokers	33,300	4,000	3,700
Never-Smokers	5,900	700	1,800

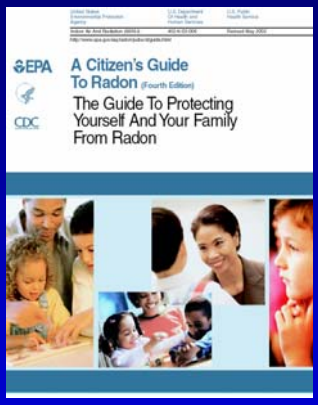
[a] Estimates based on applying same risk model to smokers and never-smokers, implying joint multiplicative relationship for Rn progeny exposure and smoking.
[b] Estimates based on applying a smoking adjustment to risk models, multiplying the baseline ERR/WLM by 0.9 for smokers and 3.0 for never-smokers.

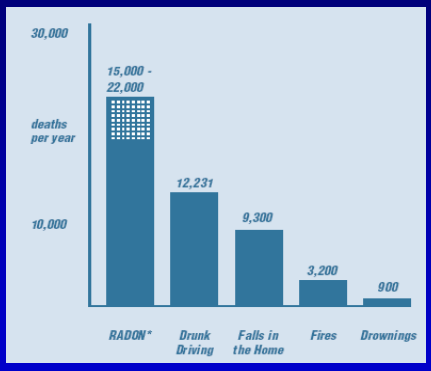
Attributable Lung Cancer Deaths





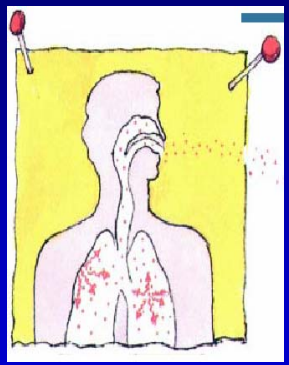






Source: EPA 2002

Scientists are more certain about radon risks than risks from most other cancer-causing substances.



Source: EPA *2002*

RADON RISK IF YOU SMOKE

Radon Level	If 1,000 people who smoked were exposed to this level over a lifetime...	The risk of cancer from radon exposure compares to...	WHAT TO DO: Stop Smoking and...
20 pCi/L	About 135 people could get lung cancer	• 100 times the risk of drowning	Fix your home
10 pCi/L	About 71 people could get lung cancer	• 100 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 57 people could get lung cancer		Fix your home
4 pCi/L	About 29 people could get lung cancer	• 100 times the risk of dying in an airplane crash	Fix your home
2 pCi/L	About 15 people could get lung cancer	• 2 times the risk of dying in a car crash	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 9 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L	About 3 people could get lung cancer	(Average outdoor radon level)	

Note: If you are a former smoker, your risk may be lower.

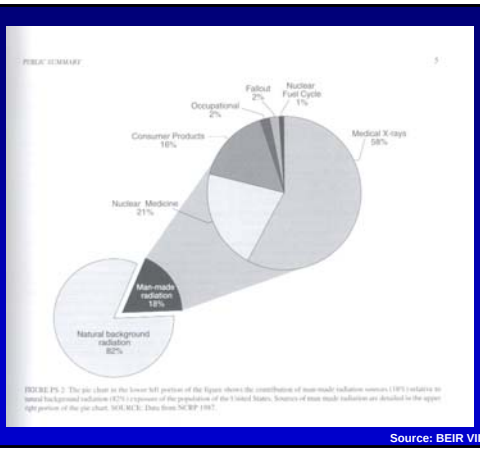
Source: EPA 2002

RADON RISK IF YOU'VE NEVER SMOKED

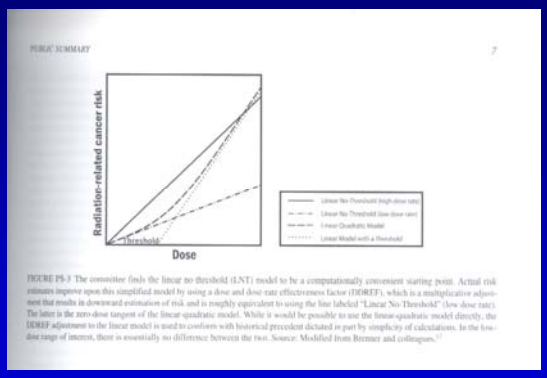
Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime. . .	The risk of cancer from radon exposure compares to. . .	WHAT TO DO:
20 pCi/L	About 8 people could get lung cancer	♦ The risk of being killed in a violent crime	Fix your home
10 pCi/L	About 4 people could get lung cancer		Fix your home
8 pCi/L	About 3 people could get lung cancer	♦ 10 times the risk of dying in an airplane crash	Fix your home
4 pCi/L	About 2 people could get lung cancer	♦ The risk of drowning	Fix your home
2 pCi/L	About 1 people could get lung cancer	♦ The risk of dying in a home fire	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	Less than 1 person could get lung	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult)
0.4 pCi/L		(Average outdoor radon level)	

Note: If you are a former smoker, your risk may be higher. Also, based on information from the National Academy of Sciences 1998 report, *The Health Effects of Exposure to Radon*, your radon risk may be higher than shown, even if you have never smoked.

Source: EPA 2002



Source: BEIR VII 2006



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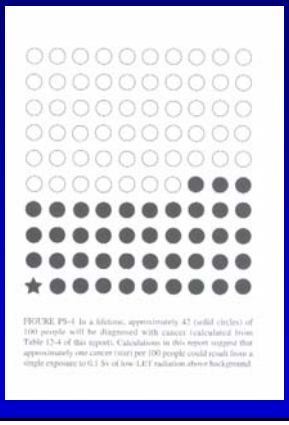

Source: BEIR VII 2006

Exercises in Risk Communication

1. **You are on the BEIR VI Committee, which estimates that from 15,400 to 21,800 lung cancer deaths per year can be attributed to radon.**
2. **You care out a case-control study of cell phone use and brain cancer. You estimate that the OR for ever use is 1.01 (95% CI 0.62-1.95).**
3. **You estimate that lifetime lung cancer risk for a smoking uranium miner is 25%.**
4. **You find that the relative risk for brain cancer increases by 2% for each dental X-ray (0.5-5%) across the life span.**