Estimating Risk of Low Radiation Doses (from AAPM 2013)

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Nordic Trauma, 20140521

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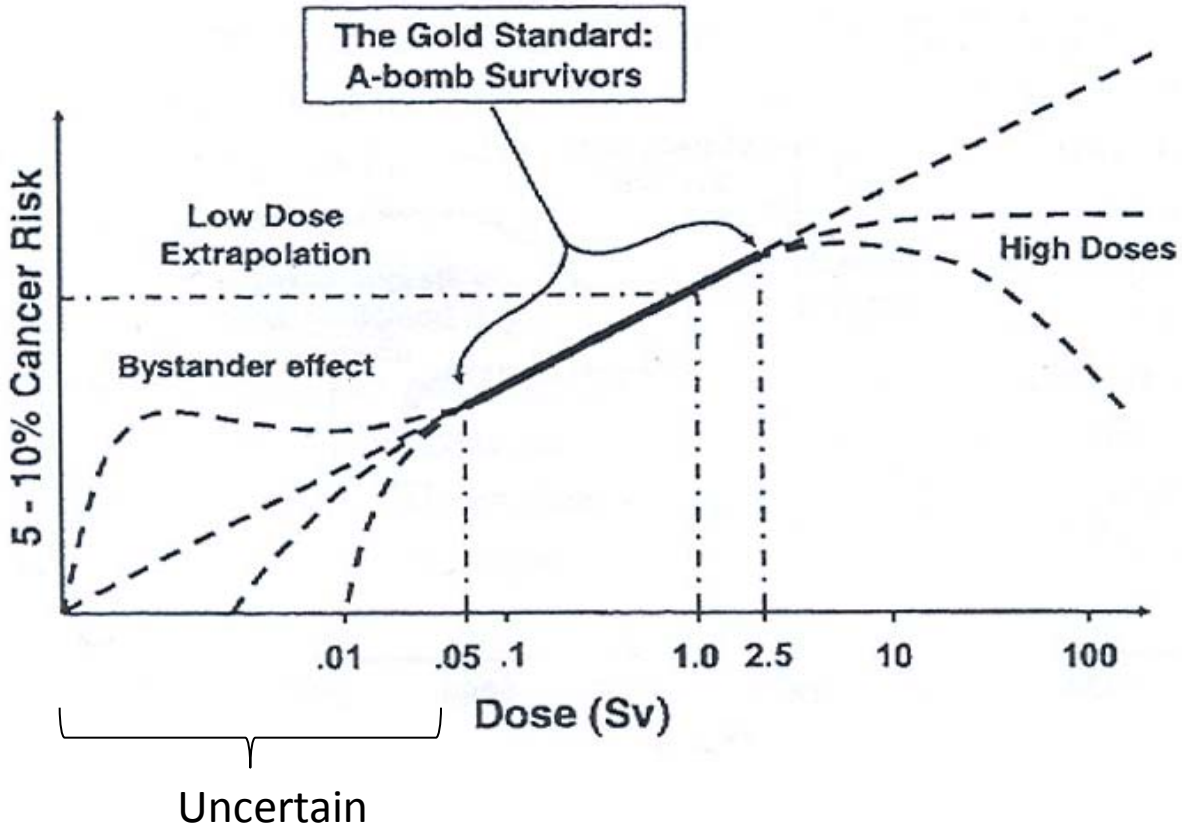
Stochastic effects

”Linear No Threshold ” - LNT-model



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- Material produced by William R. Hendee and Michael K. O'Connor, arranged by María Marteinsdóttir
  - From article:
    - *Radiation Risks of Medical Imaging: Separating Fact from Fantasy*
      - Radiology: Volume 264: Number 2 – August 2012
  - From 55th Annual Meeting AAPM 2013 - Session: MO - F-103
    - *Estimating Risk of Low Radiation Doses*
      - W Hendee[1]*, M O'Connor[2]*, E Calabrese[3]*, (1) Rochester, MN, (2) Mayo Clinic, Rochester, MN, (3)
      - http://www.aapm.org/meetings/2013AM/PRHandouts.asp

ORIGINAL INVESTIGATION

Projected Cancer Risks From Computed Tomographic Scans Performed in the United States in 2007

Amy Berrington de González, DPhil; Mahadevappa Mahesh, MS, PhD; Kwang-Pyo Kim, PhD; Mythreyi Bhargavan, PhD; Rebecca Lewis, MPH; Fred Mettler, MD; Charles Land, PhD

Estimates that 29,000 future cancers and 14,500 deaths are related to CT scans performed in the U.S. in 2007.

Arch Intern Med. 2009;169(22):2078-2086

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ORIGINAL INVESTIGATION

Radiation Dose Associated With Common Computed Tomography Examinations and the Associated Lifetime Attributable Risk of Cancer

Rebecca Smith-Bindman, MD; Jafi Lipson, MD; Ralph Marcus, BA; Kwang-Pyo Kim, PhD; Mahadevappa Mahesh, MS, PhD; Robert Gould, ScD; Amy Berrington de González, DPhil; Diana L. Miglioretti, PhD

Estimates one in 270 women (1 in 600 men) who undergo CT coronary angiography will develop cancer from the CT scan.

Arch Intern Med. 2009;169(22):2078-2086

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Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall,
D.Phil., D.Sc. N Engl J Med 2007; 357:2277-2284, November 29, 2007

1.5 – 2 % all cancers in United States caused by CT exams

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(Reuters) - Radiation from CT scans done in 2007 will cause 29,000 cancers and kill nearly 15,000 Americans, researchers said on Monday.

International New York Times

We Are Giving Ourselves Cancer

By RITA F. REDBERG and REBECCA SMITH-BINDMAN JAN. 30, 2014

A 2009 study from the National Cancer Institute estimates that CT scans conducted in 2007 will cause a projected 29,000 excess cancer cases and 14,500 excess deaths over the lifetime of those exposed

According to our calculations, unless we change our current practices, 3 percent to 5 percent of all future cancers may result from exposure to medical imaging

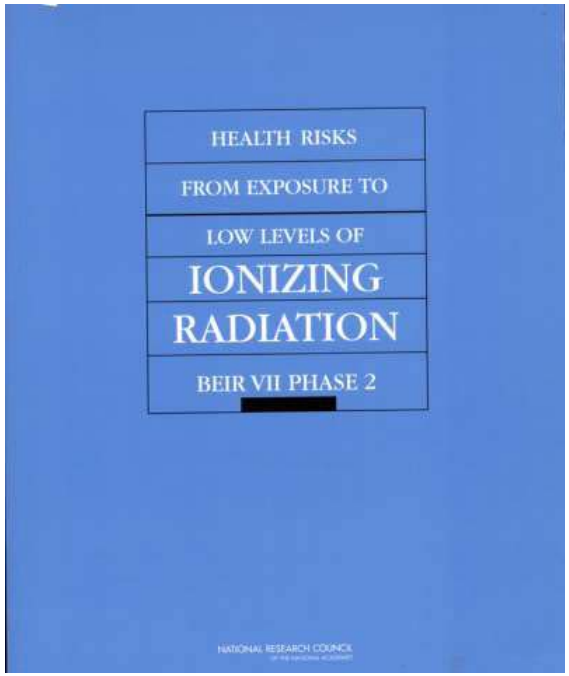
Neither doctors nor patients want to return to the days before CT scans. But we need to find ways to use them without killing people in the process.

- What are the data that led to these numbers and how dependable are these data?

- Provokes anxiety in patients and families which may make them reluctant to agree to imaging procedures that would very much be in their best interest.

Sources of Data of Stochastic Effects of Radiation

Biological Effects of Ionizing Radiation (BEIR) - 2007



National Academy of Science – National Research Council

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1. Sources of data – BEIR VII

- Several epidemiologic studies past 6 decades
  - Environmental Radiation Studies
  - Occupational Radiation Studies
  - Medical Radiation Studies
  - Atomic bomb survivor Studies
    - Radiation Effects Research Foundation - RERF ← Weighted heavily

Atomic Bomb Survivor Studies (RERF)

- 120,000 survivors
- Monitored over 60 years
- Dose range

37,000	0-5 mSv
32,000	5-100 mSv
17,000	100-2000 mSv

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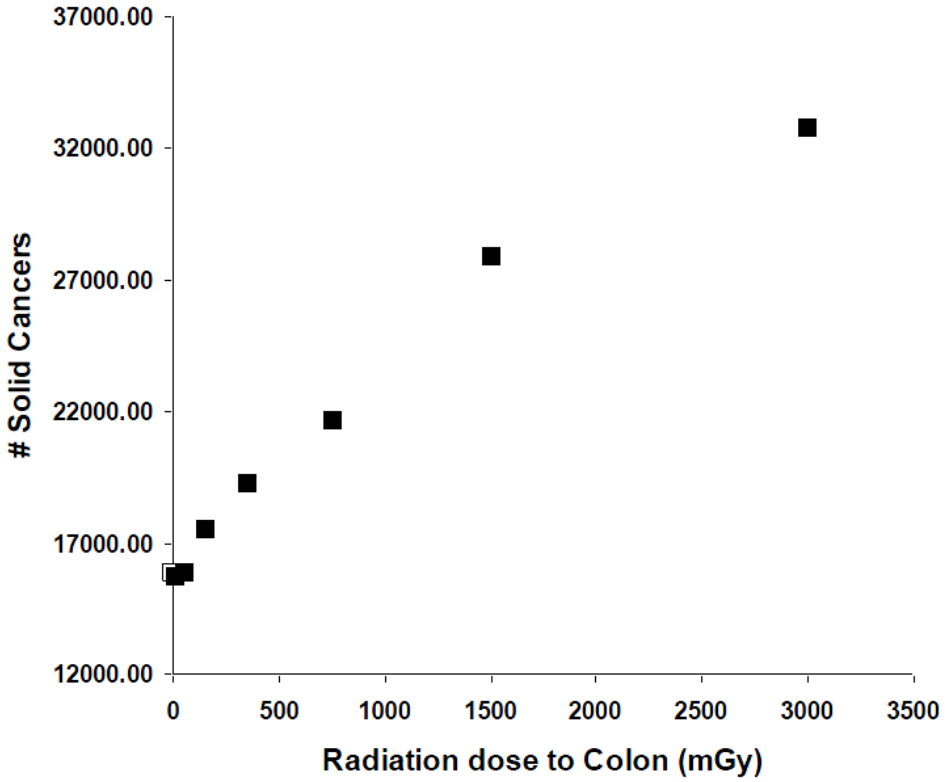
Atomic Bomb Survivor Studies (RERF)

- RERF personnel emphasized the limitations in estimates of radiation risk at low doses
  - Pierce and Preston (2003) noted that at levels less than 100 mSv, assessing cancer risks " greatly strains any epidemiological investigation since, within the scope of a study, cancer rates may vary to at least that degree due to other risk factors correlated with the exposure under investigation"

Sources of data used in BEIR VII
Atomic bomb survivor Studies

- Data from Table 4, Preston et al, 2007
- # solid cancers adjusted to per 100,000 people
- Colon cancer is depicted because it is commonly used as cancer indicator in the Japanese population



Preston et al, Rad Res 2007;168: 1-64.
(Radiation Effects Research Foundation)

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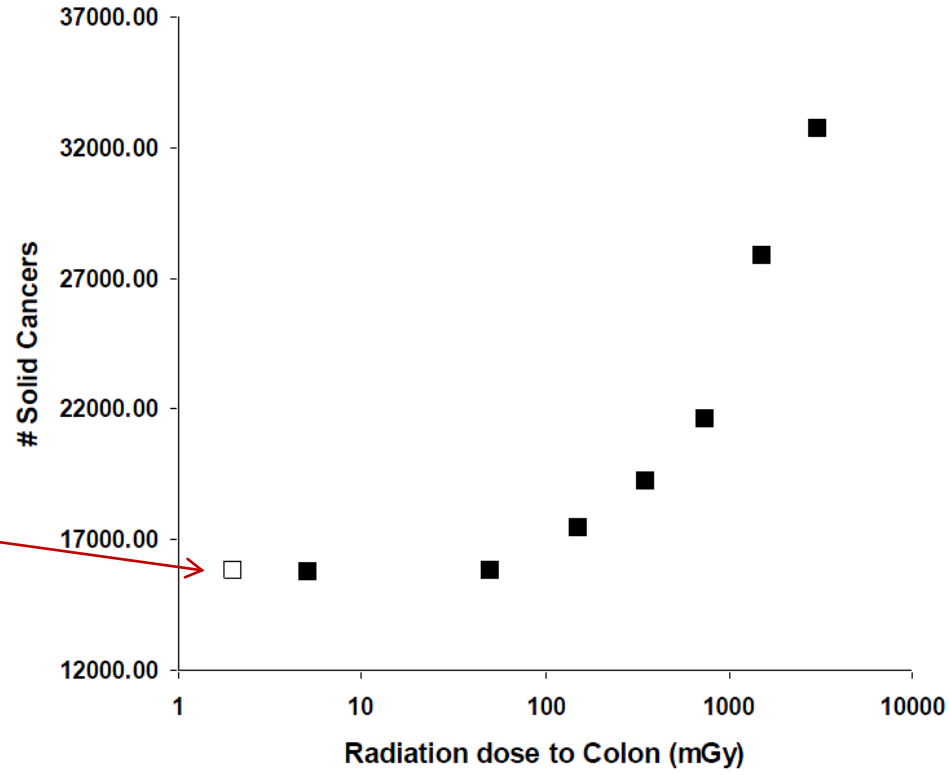
Sources of data used in BEIR VII
Atomic bomb survivor Studies

- Data from Table 4, Preston et al, 2007
- # solid cancers adjusted to per 100,000 people

NIC - People who were not in the cities at the time of the bombing



Preston et al, Rad Res 2007;168: 1-64.
(Radiation Effects Research Foundation)

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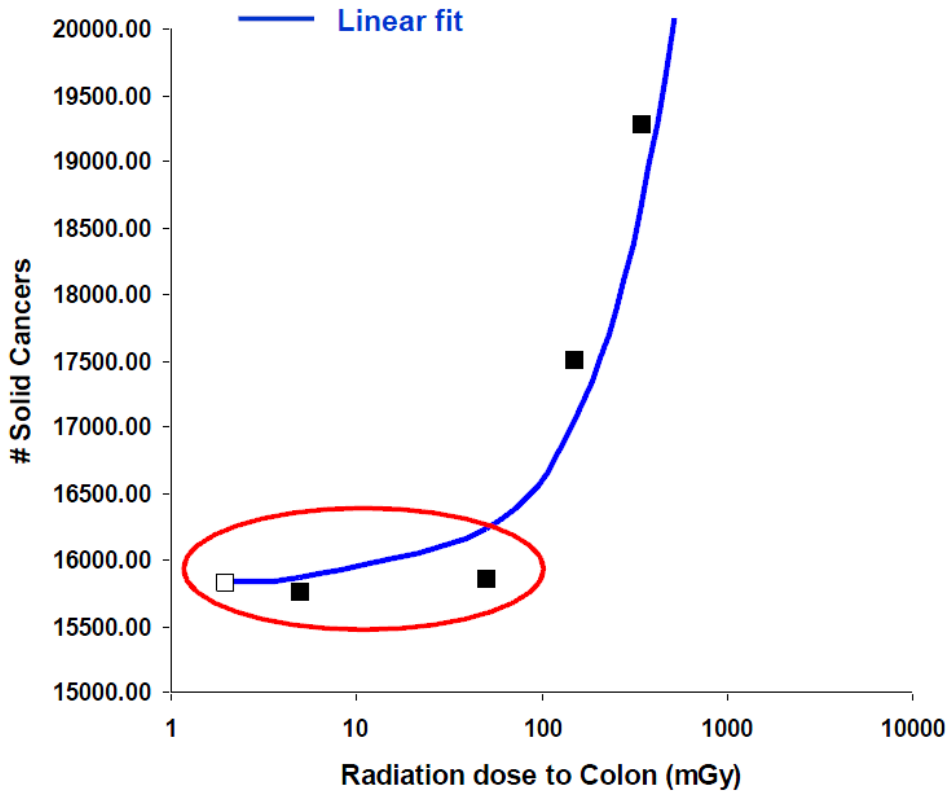
Sources of data used in BEIR VII
Atomic bomb survivor Studies

"Based on fitting with lower threshold, best estimate of threshold was 40 mGy with upper bound of 85 mGy (90% CI). However model not significantly better than LNT"



Preston et al, Rad Res 2007;168: 1-64.
(Radiation Effects Research Foundation)

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2. Linear No-Threshold Hypothesis

- LNT model for radiation effect appeared in the 1920s in Hermann Muller´s publications of genetic mutation in fruit flies induced by exposure to x-rays

- Muller won the Nobel price 1946
  - At that time there was substantial evidence that LNT model was inappropriate for x-ray induced mutation – threshold appeared to exist

- BEIR committees have extended the LNT model from mutagenesis to carcinogenesis at low doses without solid biological or epidemiological justification

3. Risk Models used in LNT

Excess Relative Risk (ERR)

vs.

Excess Absolute Risk (EAR)

Which model is correct ?

Risk Models used in LNT

BEIR VII:
What it does say:

- All estimates are based on multiple models and assumptions
- Regard specific estimates with a healthy skepticism
- Confidence intervals are “subjective” and partly based on opinion

Unfortunately many studies quote cancer estimates from BEIR VII as if they were a proven scientific fact !!!

4. Modifying Parameters

- Dose & Dose Rate Effectiveness Factor (DDREF)
  - Range of values 1.1 – 2.5 (possible range 1-40)
- Relative Biological Effectiveness (RBE)
  - Range of values 1 – 4
- Latency period
  - Range 2 – 10 years
- Ethnicity, Environment (diet, lifestyle)
  - Convert cancer risk in Japanese subject in 1940's to American subject in 2011 !

Estimate of Cancer Incidence based on

Theory:

Linear No Threshold (LNT) Hypothesis

Source of Data:

Based almost exclusively on Atomic Bomb Survivors Study

Risk models:

Excess Relative Risk (ERR)

Excess Absolute Risk (EAR)

Lifetime Attributable Risk (LAR)

Parameters:

Dose & Dose Rate Effectiveness Factor (DDREF)

Relative Biological Effectiveness (RBE)

Latency period

Health Physics Society Position

- Recommends against quantitative estimation of health risks below an individual dose of 50 mSv in one year or a lifetime dose of 100 mSv above that received from natural sources

- For doses below 50-100 mSv risks of health effects are either too small to be observed or are nonexistent

Richard J. Vetter, PhD

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POSITION STATEMENT ON RADIATION RISKS FROM MEDICAL IMAGING PROCEDURES

The American Association of Physicists in Medicine (AAPM) acknowledges that medical imaging procedures should be appropriate and conducted at the lowest radiation dose consistent with acquisition of the desired information. Discussion of risks related to radiation dose from medical imaging procedures should be accompanied by acknowledgement of the benefits of the procedures.

Risks of medical imaging at patient doses below 50 mSv for single procedures or 100 mSv for multiple procedures over short time periods are too low to be detectable and may be nonexistent.

Predictions of hypothetical cancer incidence and deaths in patient populations exposed to such low doses are highly speculative and should be discouraged. These predictions are harmful because they lead to sensationalistic articles in the public media that cause some patients and parents to refuse medical imaging procedures, placing them at substantial risk by not receiving the clinical benefits of the prescribed procedures.

AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE DECEMBER 13, 2011

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IOMP Policy Statement

Prospective estimates of cancers and cancer deaths induced by medical radiation should include a statement that the estimates are highly speculative because of various random and systematic uncertainties embedded in them.

These uncertainties include dosimetric uncertainties; epidemiological and methodological uncertainties; uncertainties from low statistical power and precision in epidemiology studies of radiation risk; uncertainties in modeling radiation risk data; generalization of risk estimates across different populations; and reliance of epidemiological studies on observational rather than experimental data. Such uncertainties cause predictions of radiation induced cancers and cancer deaths to be susceptible to biases and confounding influences that are unidentifiable.

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IOMP Policy Statement

Paragraph A86 of Report 103 of the International Commission on Radiological Protection (ICRP) states that "There is, however, general agreement that epidemiological methods used for the estimation of cancer risk do not have the power to directly reveal cancer risks in the dose range up to around 100 mSv."

Further, UNSCEAR Report A-67-46, approved in May, 2012, states that "The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) does not recommend multiplying very low doses by large numbers of individuals to estimate numbers of radiation-induced health effects within a population exposed to incremental doses at levels equivalent to or lower than natural background levels."

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What I believe In

- ALARA - Doses As Low As Reasonably Achievable
- ASARA - Procedures As Safe As Reasonably Achievable
- AHARA – Benefits As High As Reasonably Achievable

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