BEIR VII: What it does and doesn’t say

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Using BEIR VII report, estimated radiation-related incident cancers

Estimated that 29,000 future cancers could be related to CT scans performed in the U.S. in 2007.....and would translate into about 14,500 cancer deaths.

Arch Intern Med. 2009;169(22):2078-2086
CT Scan Radiation May Lead to 29,000 Cancers, Researchers Warn

Popular Diagnostic Scans May Be Overused, Some Worry

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

By Julie Steenhuisen

CHICAGO | Mon Dec 14, 2009 4:30pm EST
“Boy I'm lucky I never had one of these done! I was always skeptical of this procedure. It was my intuition that told me don't go there!”.....USA Today
Where does the estimate of 29,000 cancers come from?

Based on Table 12D from BEIR VII,

+ risk estimates for
  56,900,000 patients
TABLE 12D-1 Lifetime Attributable Risk of Cancer Incidence

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</table>

NOTE: Number of cases per 100,000 persons exposed to a single dose of 0.1 Gy.
Where does Table 12D come from?

Cumulative estimate from 3 risk models
Contains numerous assumptions, opinions

Based almost exclusively on long-term follow-up of the Atomic Bomb Survivors.

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
Sources of data used in BEIR VII

- Atomic bomb survivor Studies
- Medical Radiation Studies
- Occupational Radiation Studies
- Environmental Radiation Studies
Sources of data used in BEIR VII
Atomic bomb survivor Studies

- 120,000 survivors
  93,000 present at time of bombings
  27,000 from locale, but absent at time of the bombing (excluded from analysis)

- Monitored over 60 years & includes both sexes and all ages of exposure – mean dose = 200 mSv

- Dose range
  37,000 0-5 mSv
  32,000 5-100 mSv
  17,000 100 mSv – 2000 mSv

This is the primary source of data for all risk models used in BEIR VII
“in the presence of available data, it is neither sound statistical interpretation nor prudent risk evaluation to take the view that the risk should be considered zero in some low-dose range…”
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Sources of data used in BEIR VII
Medical Radiation Studies

Focus on therapeutic studies

“...most of the information comes from studies of populations with medium to high doses”

Lung Cancer – 7 studies, 40,000 subjects
   average dose ~ 1 Gy
Breast cancer – 11 studies, 20,000 subjects
   average dose ~ 300 mGy
Sources of data used in BEIR VII
Medical Radiation Studies

ERR per Gy—breast—studies with average dose of 1 Gy or less

BEIR VII Range from ABS
Sources of data used in BEIR VII
Occupational Radiation Studies

U.S. – 9 studies
U.K. – 6 studies
Canada – 1 study
France – 1 study

Six large combined cohort studies
Combined study population > 500,000 subjects with 30-40 years of follow-up

Cumulative dose levels: 30-60 mSv
Sources of data used in BEIR VII
Occupational Radiation Studies

“....in most cases, rates for all causes and all cancer mortality in the workers were substantially lower than the reference populations.”

“Because of uncertainty in occupational risk estimates......, the committee has concluded that the occupational studies are not suitable for the projection of population-based risks.”
Sources of data used in BEIR VII
Environmental Radiation Studies

Populations living near nuclear facilities
“..no increased risk…with radiation exposure”

Populations exposed to atomic bomb testing
“..some studies (4 out of 10) show some effect”

Chernobyl
High incidence of thyroid cancer
“..no evidence of an increase in any solid cancer type to date”

Natural background (China / India)
“..did not find higher disease rates in geographical areas with high background levels..”
Risk Models

- **Excess Relative Risk (ERR)**
  - Excess risk expressed relative to background risk

- **Excess Absolute Risk (EAR)**
  - Excess risk expressed as difference between total risk and background risk

Final Risk model = $x \cdot \text{ERR} + (1-x) \cdot \text{EAR}$
where $x$ is determined by committee!
Modifying Parameters

• **Dose & Dose Rate Effectiveness Factor (DDREF)**
  - Range of values 1.1 – 2.5

• **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!
Risk Models

• **Lifetime Attributable Risk (LAR)**
  - Uses different final risk models for different organs
  - Assumptions about modifying parameters
  - Risk models then applied to cancer rates for U.S. population

• Cancer incidence in Table 12D is based on this parameter!
...range of plausible values for LAR is labeled a “subjective confidence interval” to emphasize its dependence on opinions in addition to direct numerical observation (BEIR VII, page 278)
Risk Models

• Lifetime Attributable Risk (LAR)
  • “Because of the various sources of uncertainty it is important to regard specific estimates of LAR with a healthy skepticism, placing more faith in a range of possible values” (BEIR VII, page 278)
Cancer mortality in 100,000 subjects

- U.S. Cancer Mortality
- Minnesota - 3 mSv/year
- Colorado - 4.5 mSv/year
- 50 mSv at age 40

Estimated deaths due to background radiation. No epidemiological evidence to support these numbers.
Number of subjects exposed to different radiation doses, required to detect a significant increase in cancer mortality assuming lifetime follow-up

Brenner et al, PNAS 2003; 100: 13761-13766
Where does the estimate of 29,000 cancers come from?

Based on Table 12D BEIR VII, and risk estimates for 56,900,000 patients.

For comparison: 9,700,000 people will die of cancer

IF they all lived in Minnesota, (bkg rad = 3 mSv)
we would expect 576,000 deaths from background radiation

IF they all lived in Colorado, (bkg rad = 4.5 mSv)
we would expect 863,000 deaths from background radiation

Differences in residence = 287,000 cancers, or ~10 CT scans/patient
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

Don’t quote cancer estimates from BEIR VII as if they were a proven scientific fact !!!