

BEIR VII: What it does and doesn't say

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ORIGINAL INVESTIGATION

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

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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



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CT Scan Radiation May Lead to 29,000 Cancers, Researchers Warn

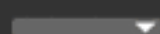
Popular Diagnostic Scans May Be Overused, Some Worry



REUTERS

EDITION:

U.S.



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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.

By [Julie Steenhuisen](#)

CHICAGO | Mon Dec 14, 2009 4:30pm EST

Cancer on  msnbc.com

15,000 will die from CT scans done in 1 year

Scans have higher levels of radiation than thought, researchers say

**Will You Be one of the 15,000 That Are Killed
By CT Scans Next Year?**

This is the question being asked as 2009 drew to a close.

Cancercare.com

“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^a

Cancer Site	Age at Exposure (years)										
	0	5	10	15	20	30	40	50	60	70	80
<i>Males</i>											
Stomach	76	65	55	46	40	28	27	25	20	14	7
Colon	336	285	241	204	173	125	122				30
Liver	61	50	43	36	30	22	21				3
Lung	314	261	216	180	149	105	104				34
Prostate	93	80	67	57	48	35	35				5
Bladder	209	177	150	127	108	79	79				23
Other	1123	672	503	394	312	198	172				23
Thyroid	115	76	50	33	21	9	3				0.0
All solid	2326	1667	1325	1076	881	602	564				126
Leukemia	237	149	120	105	96	84	84	64	62	75	48
All cancers	2563	1816	1445	1182	977	686	648	591	489	343	174
<i>Females</i>											
Stomach	101	85	72	61	52	36	35				11
Colon	220	187	158	134	114	82	79				23
Liver	28	23	20	16	14	10	10				2
Lung	733	608	504	417	346	242	240				77
Breast	1171	914	712	553	429	253	141				4
Uterus	50	42	36	30	26	18	16				2
Ovary	104	87	73	60	50	34	31	25	18	11	5
Bladder	212	180	152	129	109	79	76	74	64	47	24
Other	1339	719	523	409	323	207	181	148	109	68	30
Thyroid	634	419	275	178	113	41	14	4	1	0.3	0.0
All solid	4592	3265	2525	1988	1575	1002	824	678	529	358	177
Leukemia	185	112	86	76	71	63	62	62	57	51	37
All cancers	4777	3377	2611	2064	1646	1065	886	740	586	409	214

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

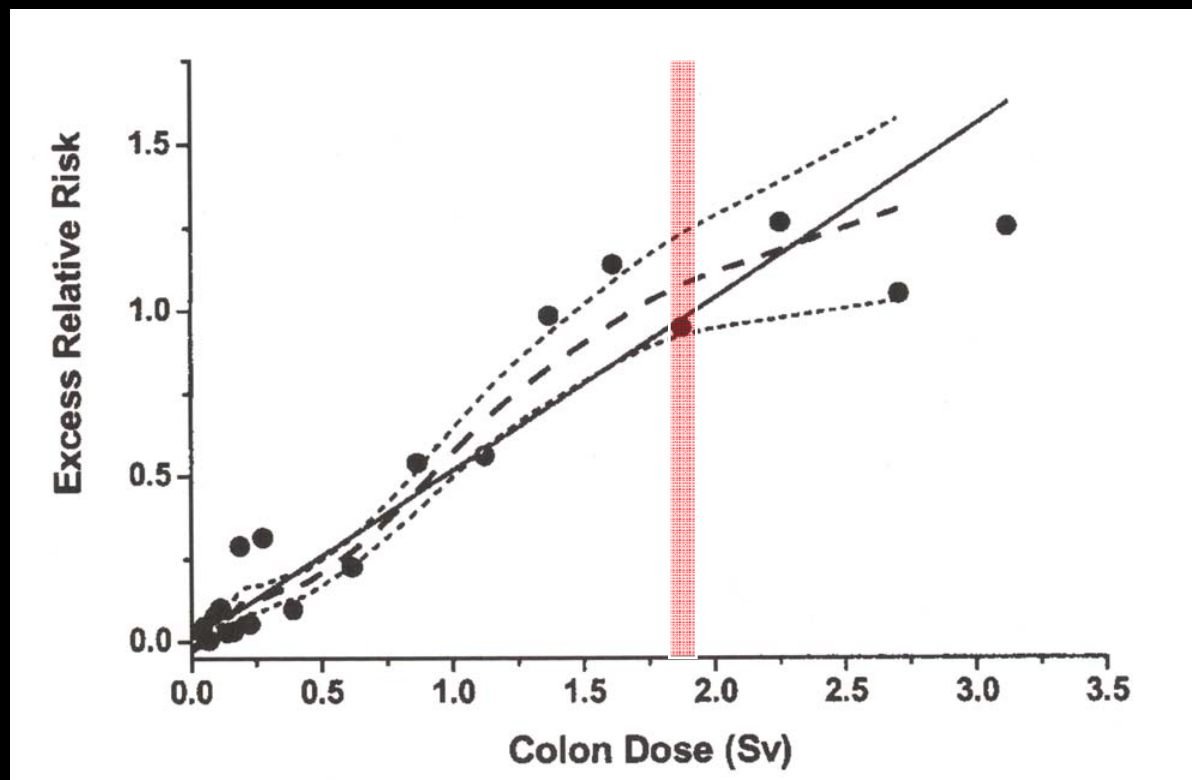
Atomic bomb survivor Studies

- **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

Sources of data used in BEIR VII

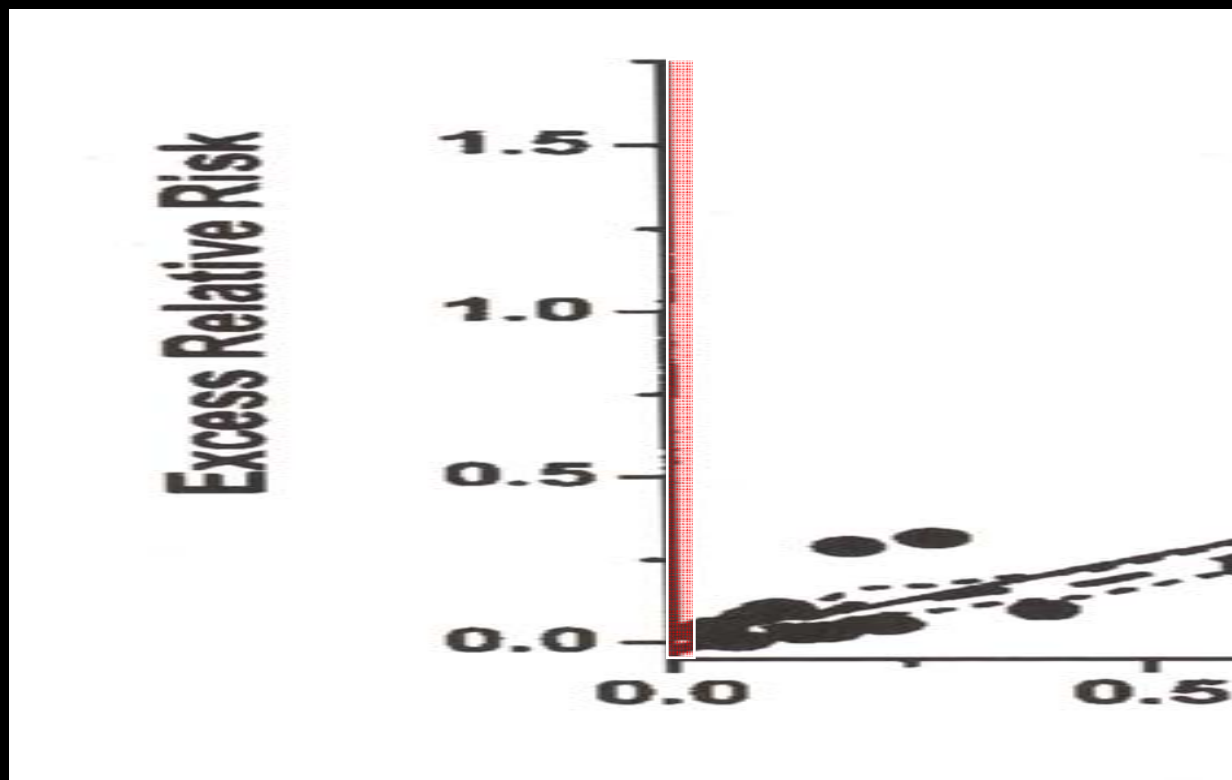
Atomic bomb survivor Studies



“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...”

Sources of data used in BEIR VII

Atomic bomb survivor Studies



“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...”

Sources of data used in BEIR VII

Medical Radiation Studies

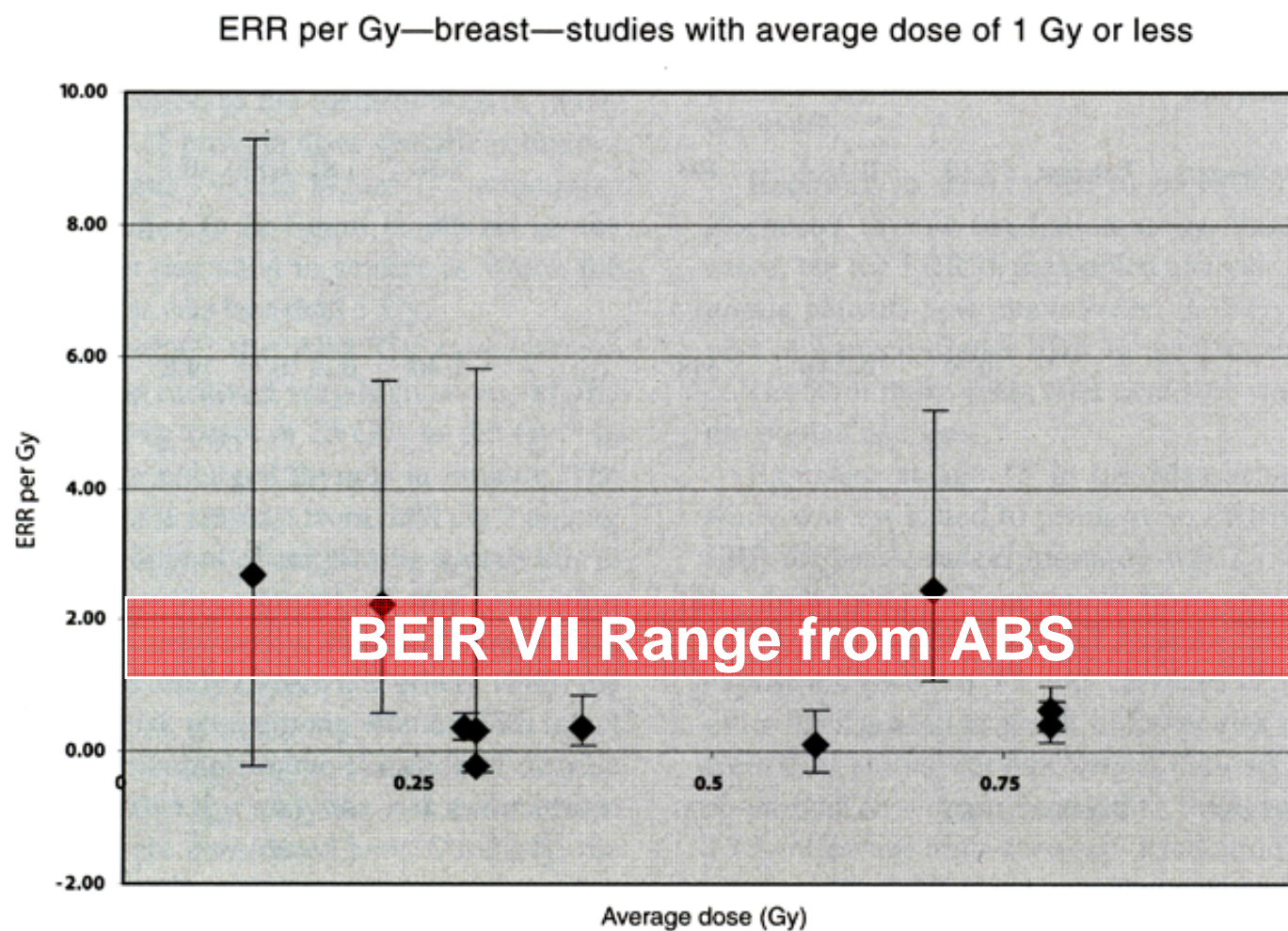
Focus on therapeutic studies

“...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



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 !**

TABLE 12-5A Lifetime Attributable Risk of Solid Cancer Incidence

Cancer Site	Males			Females		
	LAR Based on Relative Risk Transport ^a	LAR Based on Absolute Risk Transport ^b	Combined and Adjusted by DDREF ^c (Subjective 95% CI ^d)	LAR Based on Relative Risk Transport ^a	LAR Based on Absolute Risk Transport ^b	Combined and Adjusted by DDREF ^c (Subjective 95% CI ^d)
<i>Incidence</i>						
Stomach	25	280	34 (3, 350)	32	330	43 (5, 390)
Colon	260	180	160 (66, 360)	160	110	96 (34, 270)
Liver	23	150	27 (4, 180)	9	85	12 (1, 130)
Lung	250	190	140 (50, 380)	740	370	300 (120, 780)
Breast				510 Not used	460	310 (160, 610)
Prostate	190	6	44 (<0, 1860)			
Uterus				19	81	20 (<0, 131)
Ovary				66	47	40 (9, 170)
Bladder	160	120	98 (29, 330)	160	100	94 (30, 290)
Other	470	350	290 (120, 680)	490	320	290 (120, 680)
Thyroid	32	No model	21 (5, 90)	160	No model	100 (25, 440)
Sum of site-specific estimates	1400	1310 ^e	800	2310 ^f	2060 ^e	1310
All solid cancer model ^g	1550	1250	970 (490, 1920)	2230	1880	1410 (740, 2690)

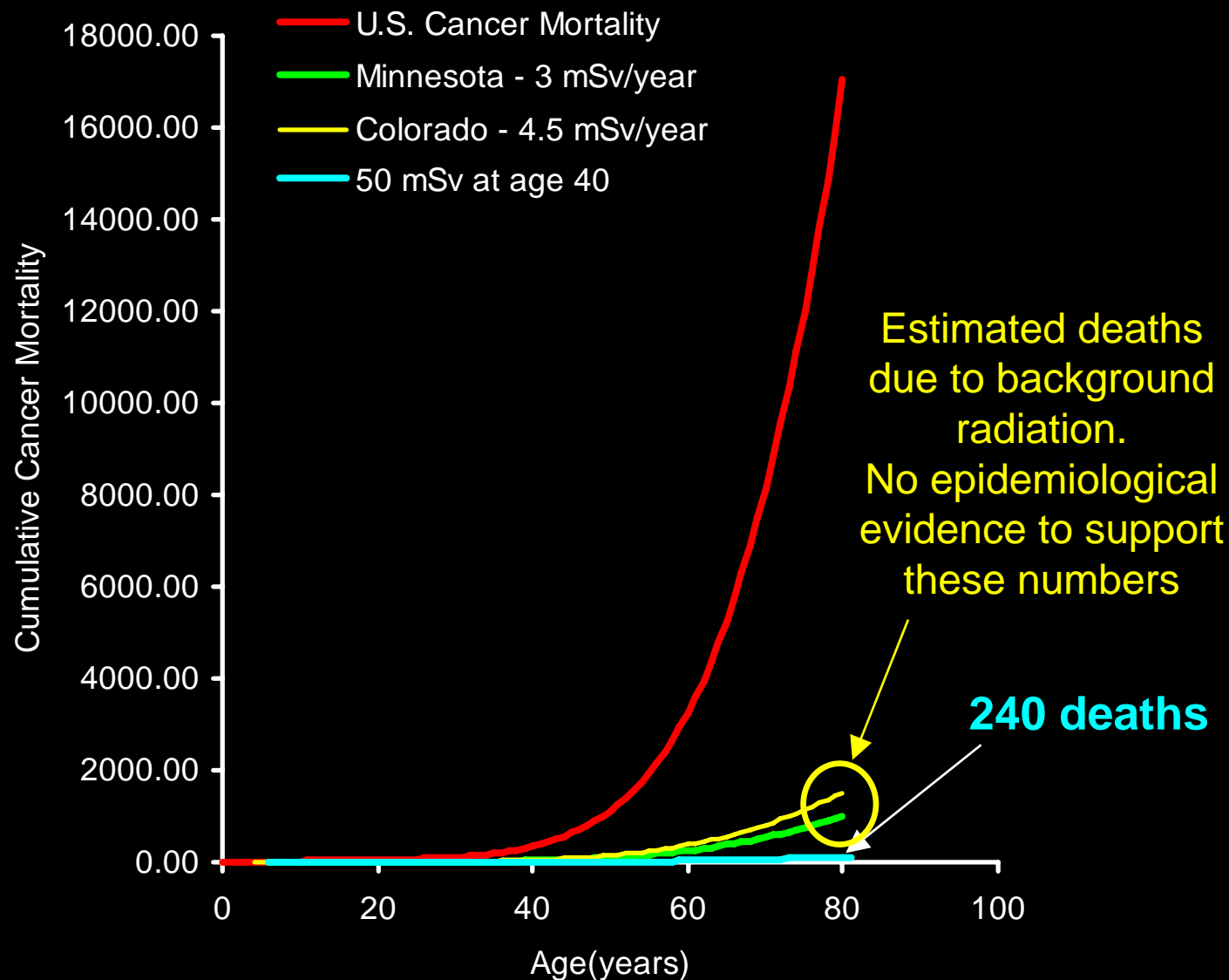
NOTE: Number of cases per 100,000 persons of mixed ages exposed to 0.1 Gy.

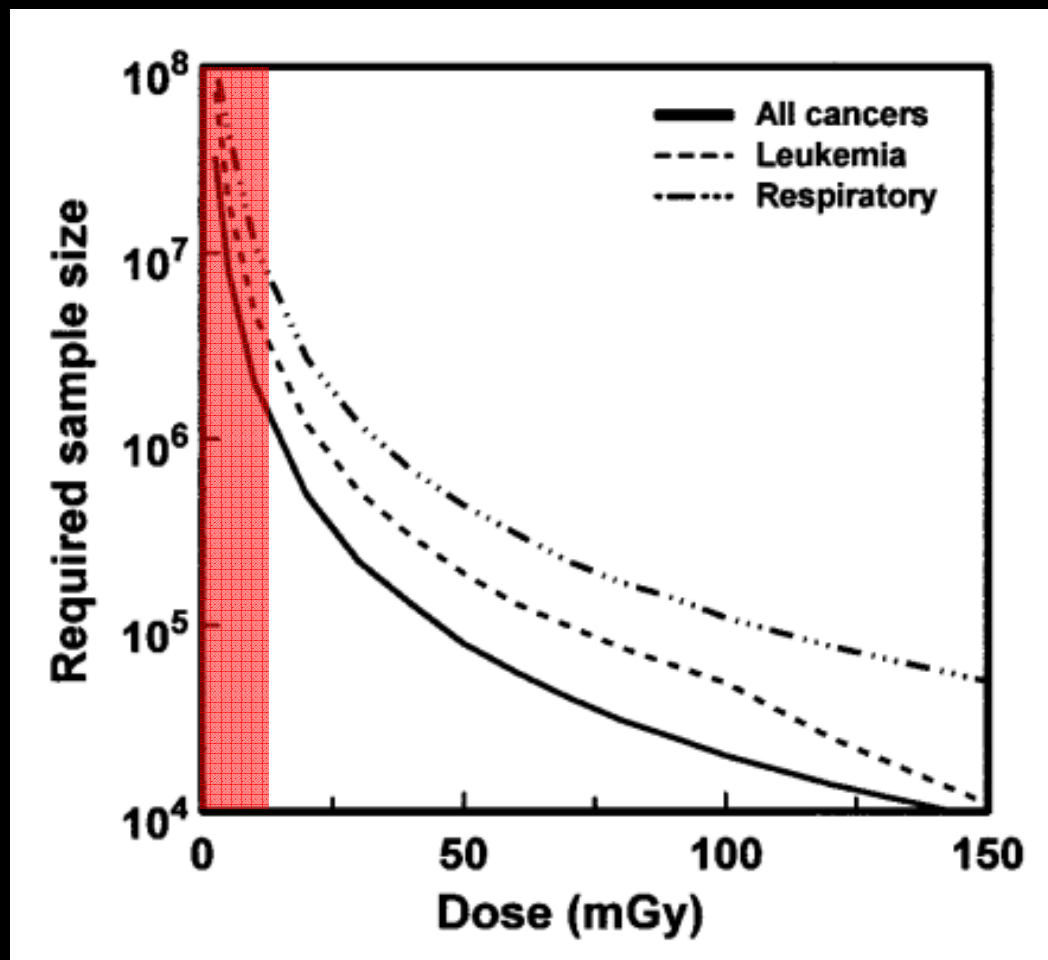
...range of plausible values for LAR is labeled a “subjective confidence interval” to emphasize its dependence on opinions in addition to direct numerical observation (BEIR VII, page 278)

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





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 !!!