Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 22-H7.62A

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Supplementary Information

Presentation from Ken Chaplin

Renseignements supplémentaires

Présentation de Ken Chaplin

In the Matter of the

À l'égard des

Canadian Nuclear Laboratories (CNL)

Laboratoires Nucléaires Canadiens (LNC)

Application from the CNL to amend its Chalk River Laboratories site licence to authorize the construction of a near surface disposal facility

Demande des LNC visant à modifier le permis du site des Laboratoires de Chalk River pour autoriser la construction d'une installation de gestion des déchets près de la surface

Commission Public Hearing
Part 2

Audience publique de la Commission
Partie 2

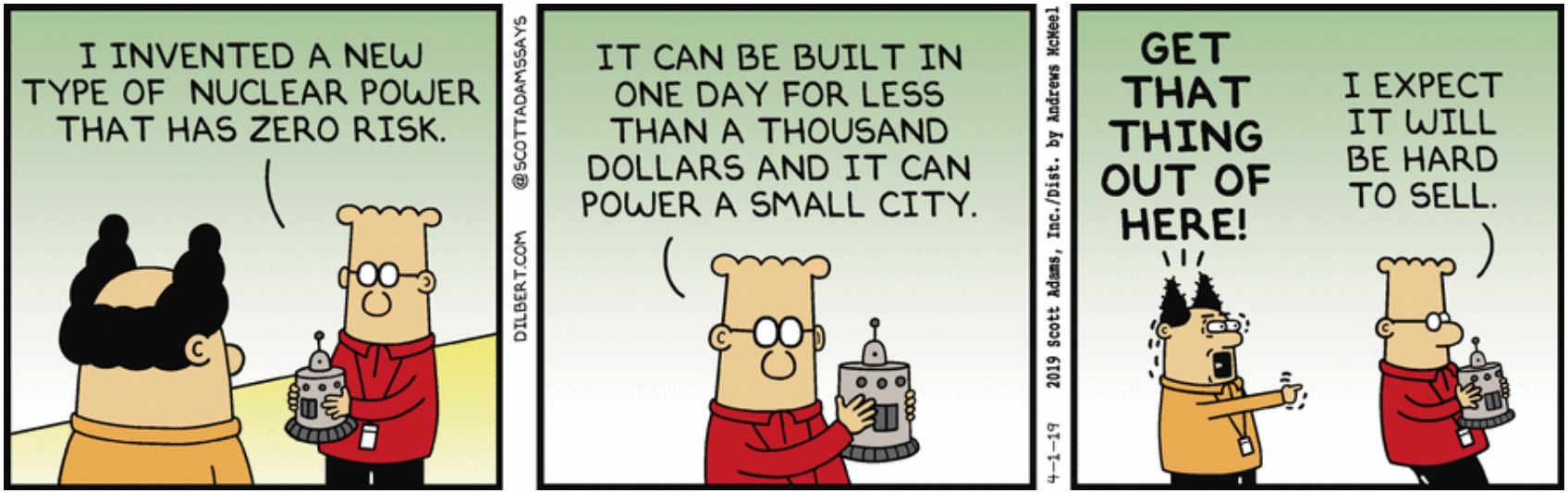
May 30 to June 3, 2022

30 mai au 3 juin 2022

Canada

Estimating Risk and the National Council on Radiation Protection's (NCRP's) Commentary 27

Ken Chaplin
AECL/CNL retired


I INVENTED A NEW TYPE OF NUCLEAR POWER THAT HAS ZERO RISK.
DILBERT.COM @SCOTTADAMSSAYS
IT CAN BE BUILT IN ONE DAY FOR LESS THAN A THOUSAND DOLLARS AND IT CAN POWER A SMALL CITY.
4-1-19 2019 Scott Adams, Inc./Dist. by Andrews McMeel
GET THAT THING OUT OF HERE!
I EXPECT IT WILL BE HARD TO SELL.

NCRP & It's Commentary 27 (2018)

"Implications of Recent Epidemiological Studies for the Linear-Nonthreshold Model and Radiation Protection"

- NCRP created by US Congress charter in 1964 to define American radiation policy
- NCRP influences the International Commission on Radiological Protection (ICRP), the CNSC, and the rest of the world

Commentary 27: Determine whether chosen epidemiological studies:

- "broadly support the LNT model of carcinogenic risk" OR
- "whether there is sufficient evidence that the LNT model is inappropriate for the purposes of radiation protection"

LNT assumed - Hormesis, biphasic, adaptive response are not mentioned

NCRP's Commentary 27 Conclusions

- Six studies "Strongly Supported" LNT:
  - 2 worker studies
  - 2 Hiroshima/Nagasaki (H/N) studies
  - 2 studies combined medical & H/N cohorts

- NCRP reaffirmed LNT as the most prudent and practical basis for radiation protection
- BUT my question is:

  Are doses in the 0-100 mGy/year range dangerous?

- Rad Protection for N-power should focus on this dose range; >100 mGy/yr doses are rarely exceeded

  >100 mGy acute doses are more rare

Overview

Do the six NCRP chosen studies:

Support LNT?

OR

A threshold of 100 mGy/year?

- I will show using one worker study, one H/N study, and one medical study that:
  - Data in the studies shows little or no harm in this dose range
  - These studies overestimate harm by their treatment of:
    Methodology/Control-Group/Confounding-Factors

- I start by accepting the calculations of Relative Risk (RR) in each bin

Worker Study 1, Leuraud et al. (1)

Ionising radiation and risk of death from leukemia and lymphoma in radiation-monitored workers (INWORKS): an international cohort study; 2015 Leuraud et al. (1)

- 308,000 workers, many involved in N-weapons, 13% women, time range of 1945 to 2005, 22% died

- "Findings: Doses were accrued at very low rates (mean 1·1 mGy/yr …). The ERR of leukemia mortality (excluding chronic lymphocytic leukemia) was 2·96 per Gy (90% CI 1·17–5·21; lagged 2 years), most notably because of an association between radiation dose and mortality from chronic myeloid leukemia (excess relative risk per Gy 10·45, 90% CI 4·48–19·65)."

- "Interpretation: This study provides strong evidence of positive associations between protracted low-dose radiation exposure and leukemia. "

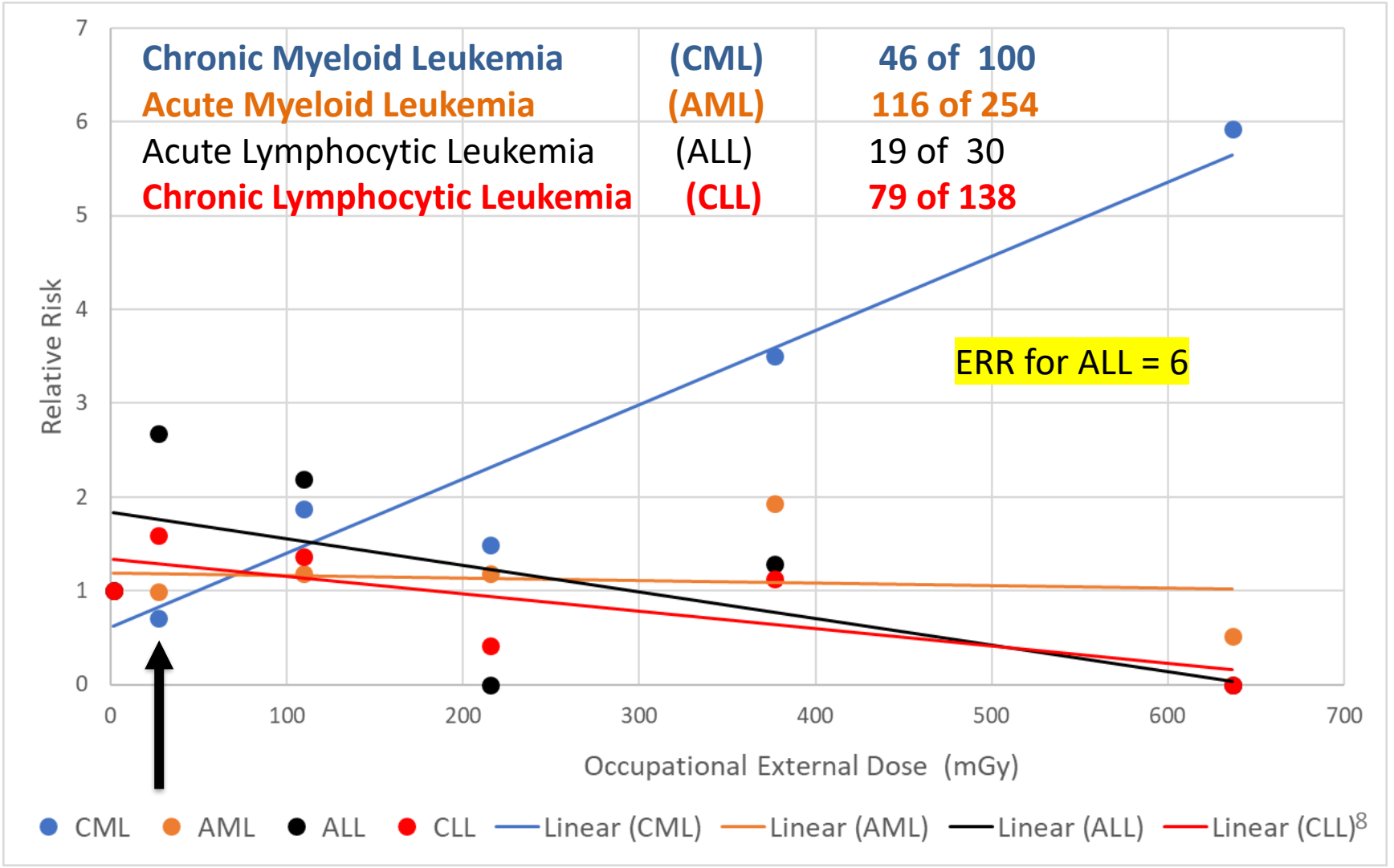
Worker Study 1, Leuraud et al. (2)

Specific Points to Make

- Abstract and conclusions are not supported by the data
- Methodology used strongly supports LNT even when the data does not
- Even if one believes that the data supports greater CML beyond occupational dose LNT, causality is not demonstrated

Worker Study 1, Leuraud et al. (3)

- Four types of leukemia & three of lymphoma analysed, only leukemia has positive association
- CML has a positive dose response, but what does it mean?



Worker Study 1, Leuraud et al. (4)

What does CML data show?

- Little or no evidence of an increase in CML in low dose range
- LNT is not an appropriate model
- Significant evidence of an increase in CML in high dose range
- Does this dose response imply causation?

Dose Range (mGy)	# of Workers	CML Deaths				
		Expected	Observed	Excess	Predicted by ERR	Error in Prediction
Reference (0-8)	~203,000	54	54	0.0	54	0.0
Low (8-320)	~101,000	41.1	38	-3.1	55.7	17.7
High (320+)	~4,000	1.8	8	6.2	7.6	-0.4
Total	308,000	96.9	100.0	3.1	117.3	17.3

Worker Study 1, Leuraud et al. (5)

Analysis is done of leukemia excluding CLL, 181 cancers with radiation exposure are of interest out of a total of 354 in a group of 308,000.

Instead: What can be learned from the 8 relevant cancers?

	Date of Death	Age at Death	Where did they work? On What?	Total RBM Dose	First Year in Dose Registry	Last Year in Dose Registry	Total Dose	Max Dose in a Year
CML 1								
…								
CML 8								

IF CML death is > x years after retirement, then it is likely not from radiation
IF CML death is < y years after start of work, then it is likely not from radiation
IF several deaths in workers in a particular job/location, then cause could be found
IF total Dose from all sources is large, then it is not low/protracted
IF max dose in a year is >> 100 mGy, then this could be a cause

H/N Study 1, Grant et al. (1)

"Solid Cancer Incidence Among the Life Span Study of Atomic Bomb Survivors: 1958–2009" Grant et al., 2017

- 105,000 subjects:

  Reference Group is 25,000 "Not In City" and 36,000 < 5 mGy dose

  Exposed Group is 44,000 with ~11,000 Gy, <u>contamination not counted</u>

Findings

- 22,538 incident first solid cancer cases, 992 associated with radiation
- "Females … ERR of 0.64 per Gy … males … ERR of 0.010 … at 0.1 Gy"
- "The lowest dose range that showed a statistically significant dose response using the sex-averaged, linear ERR model was 0–100 mGy"

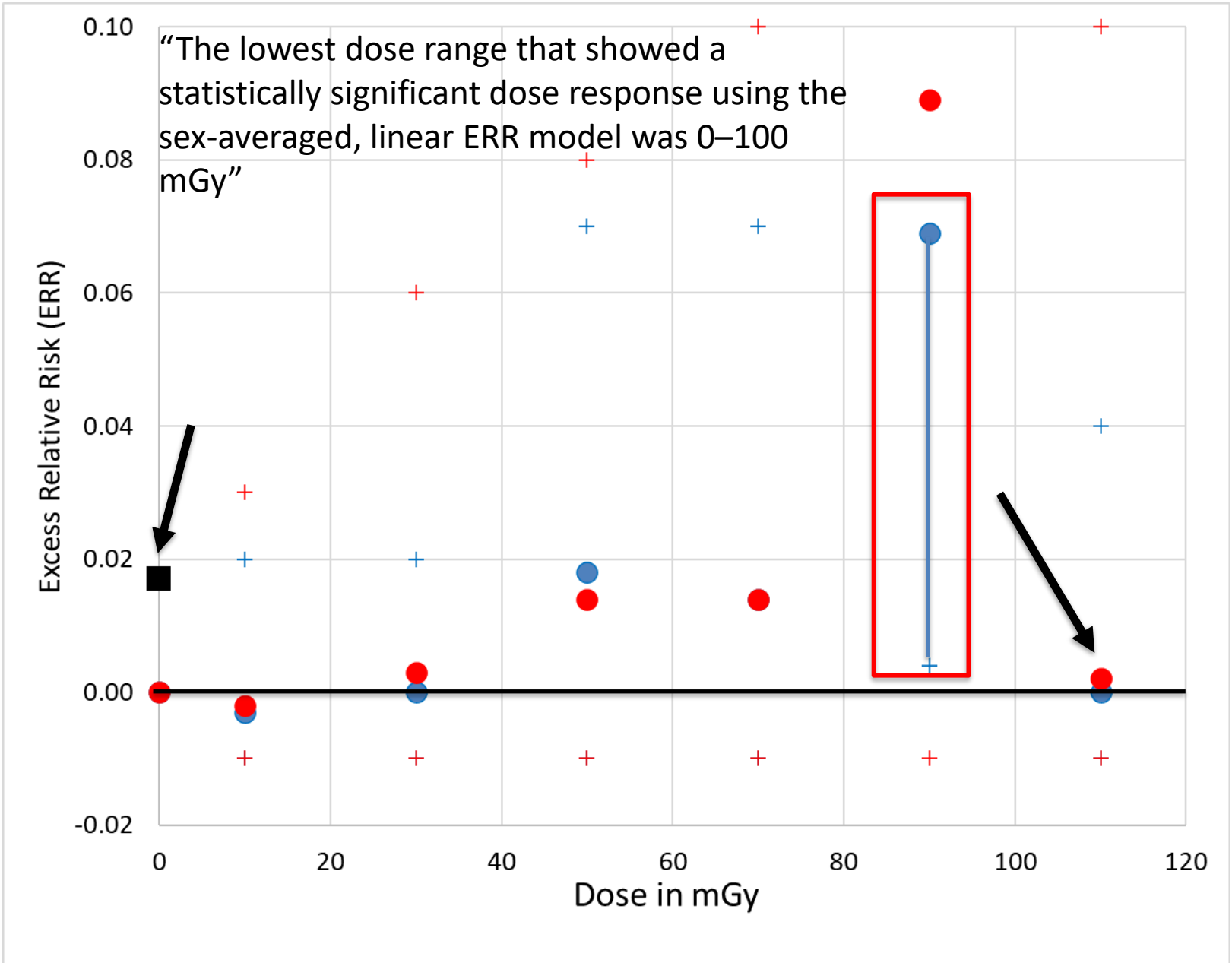
H/N Study 1, Grant et al. (2)

Specific Points to Make

- We are only interested in low dose range, here 0-125 mGy. About 90% of subjects are in this range, including the reference group
- The reference group is arbitrary to some extent
- Applying results to Fukushima workers, 202 instead of 200 cancers
- Uncertainties in dose and the reference group are not adequately compensated for
- NSDF – Doses/Dose-rates are 3/7 orders of magnitude lower than the evidence at 0.1 Gray/hour

H/N Study 1, Grant et al. (4)

Male & Female ERR (Table E1): After Smoking Accounted For



H/N Study 1, Grant et al. (3)

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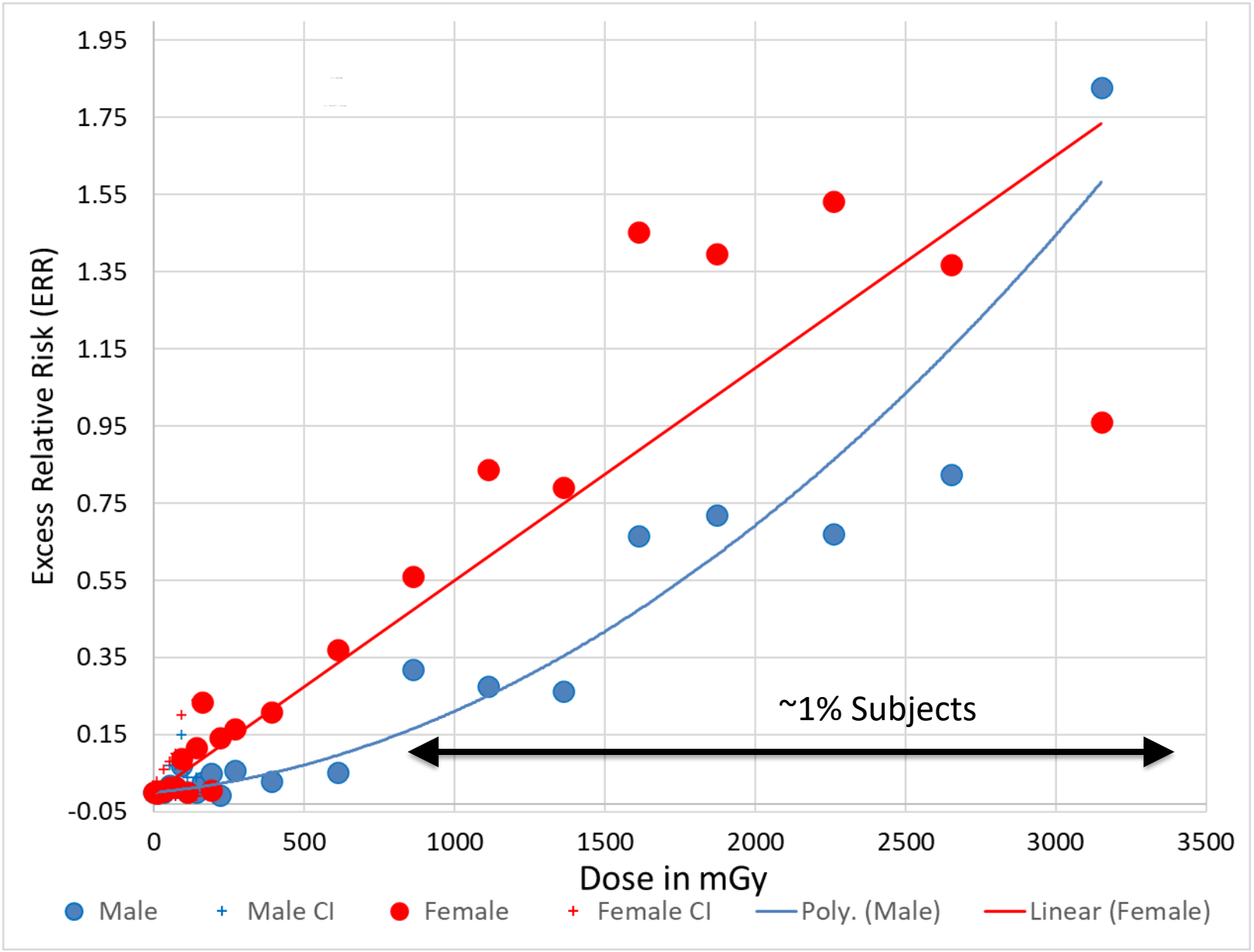


Medical Study 1, Lubin et al. (1)

"Thyroid Cancer Following Childhood Low-Dose Radiation Exposure: A Pooled Analysis of Nine Cohorts"

- **"Objectives:** Evaluation of RR for thyroid radiation doses <=200 milli Gray (mGy);

- **Participants:** There were 252 cases and 2,588,559 person-years in irradiated individuals and 142 cases and 1,865,957 person years in nonirradiated individuals.

- **Results:** For both <200 and <100 mGy, RRs increased with thyroid dose. Estimates of threshold dose ranged from 0.0 to 30 mGy, with an upper 95% confidence bound of 40 mGy.

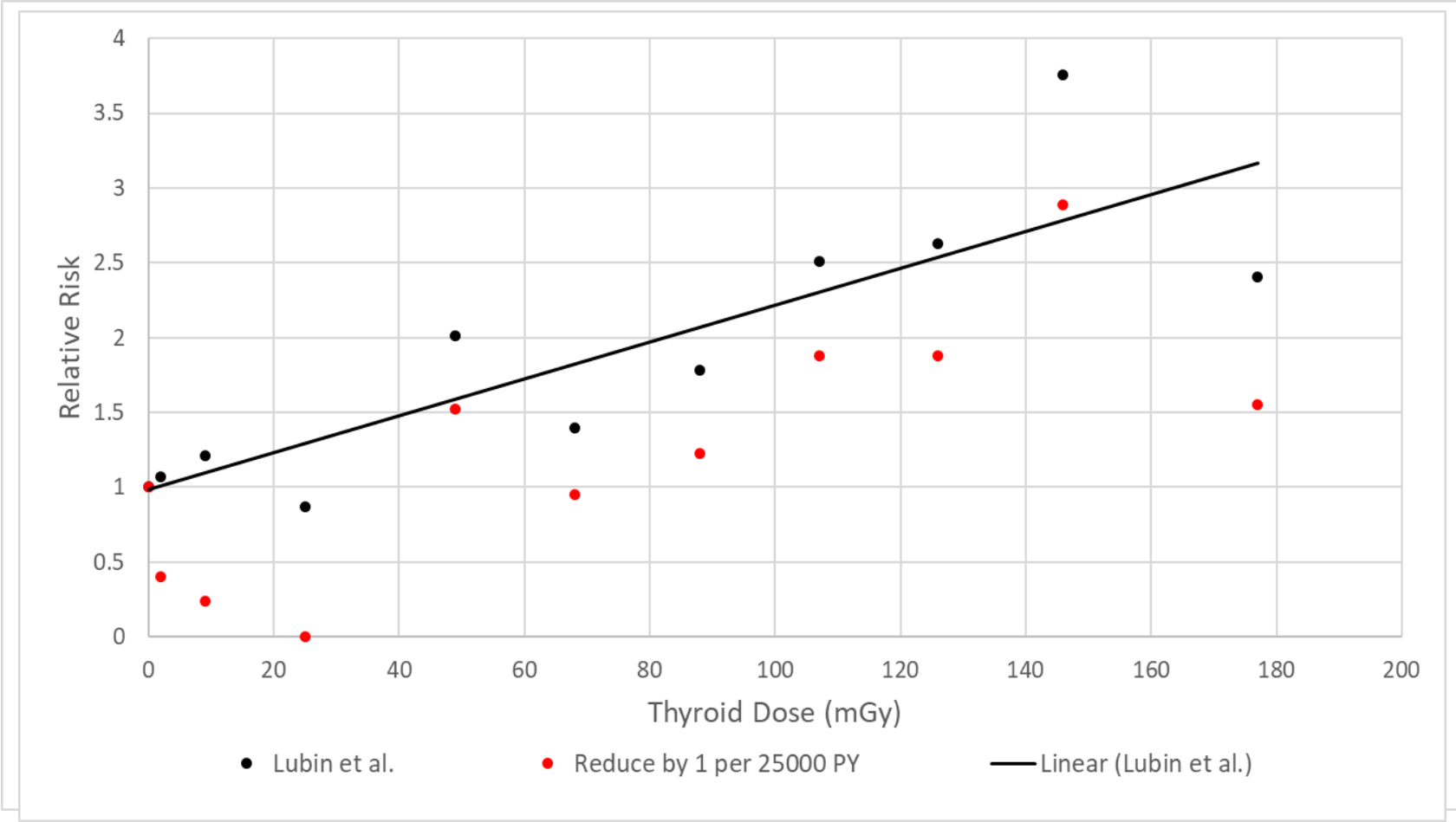
Medical Study 1, Lubin et al. (2)

Specific Points to Make

- Plotting of data favors LNT
- Although there are nine cohorts, removing one cohort makes radiation appear benign
- This is a worst case study: huge & acute doses to the body, just children, just thyroid, all harm attributed to radiation
- The NCRP claims this supports LNT, but how general is this study: just children, just thyroid, just external doses
- A major confounding factor is not controlled for

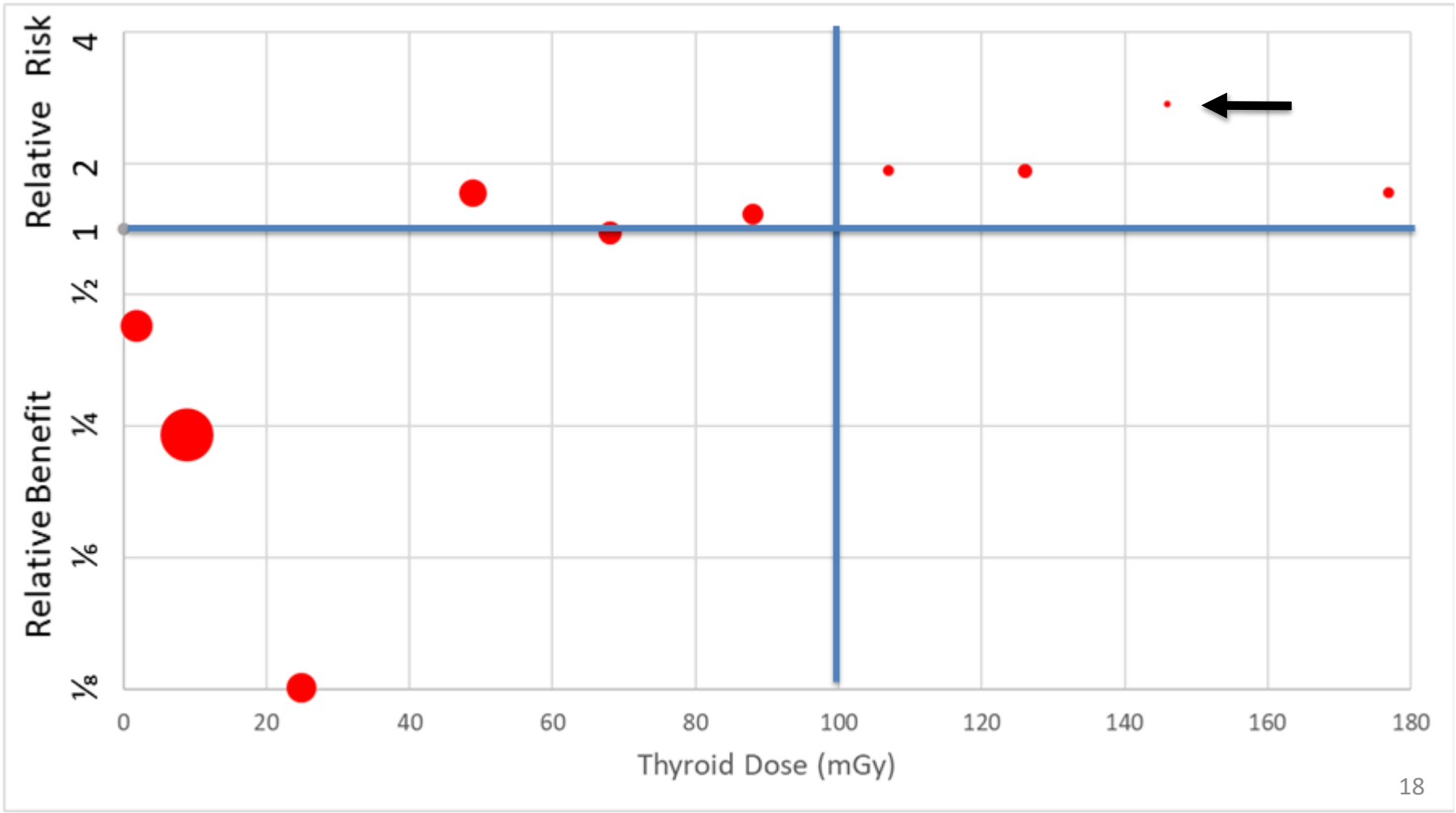
Medical Study 1, Lubin et al. (3)

- ~60 extra cases in 60,000 exposed subjects
- The effect is due to 1 in 9 cohorts (Israeli study)
- More screening is expected due to radiation dose
- Thyroid cancer in US & Korea rose significantly due to screening (15 times for Korea)



Medical Study 1, Lubin et al. (3)

- Red dots in above slide re-ploted below with a scale that displays Relative Risk (RR) of ¼ and RR=4 at the same distance from RR=1. So scale is proportional to the effect of radiation.
- Dot diameters are proportional to PY. Shows possible weighting.



Summary

- Similar methodology used in all studies (biased plots, high ERR?)
- LNT assumed from the start (ERR)

<u>Looking only at the worker study due to time constraints</u>

- Study uses photon dose to organ
  - INSTEAD use total dose to body
- Study uses admin/scientific staff as control group
  - INSTEAD use local trades workers
- Confounding effects are not adequately considered
  - INSTEAD consider annual doses > 100 mGy as confounding effect
- Uncertainties underestimated
  - Likely there is large missing dose
  - Dose boundaries in bins have an effect
  - Control group has uncertainty

Conclusions

- Six studies show little or no evidence of harm in the 0-100 mGy range

- We should assign a safe level of radiation

Worker Study 1, Leuraud et al. (3)

Supplementary Information has results of Dose Lagging, used to deal with latency of disease

	Deaths	Dose, 2-y lagged			Dose, 10-y lagged		
		ERR per Gy	90% CI	LRT (*p*)	ERR per Gy	90% CI	LRT (*p*)
Leukaemia excluding CLL	531	2·96	1·17–5·21	8·85 (0·0029)	3·57	1·52–6·14	10·29 (0·0013)
Chronic myeloid leukaemia	100	10·45	4·48–19·65	14·13 (0·00017)	11·93	5·00–22·85	13·94 (0·00019)
Acute myeloid leukaemia	254	1·29	-0·82–4·28	0·86 (0·35)	1·89	-0·56–5·38	1·46 (0·23)
Acute lymphoblastic leukaemia	30	5·80	<0–31·57	0·86 (0·36)	5·35	<0–32·05	0·71 (0·40)
CLL	138	-1·06	<0–1·81	0·61 (0·44)	-0·85	<0–2·74	0·23 (0·63)
Multiple Myeloma	293	0·96	-0·77–3·33	0·71 (0·40)	0·84	-0·96–3·33	0·48 (0·49)
Non Hodgkin lymphoma	710	0·40	-0·75–1·82	0·28 (0·60)	0·47	-0·76–2·03	0·34 (0·56)
Hodgkin's lymphoma	104	1·14	<0–6·85	0·23 (0·63)	2·94	<0–11·49	0·75 (0·39)

Worker Study 1, Leuraud et al. (5)

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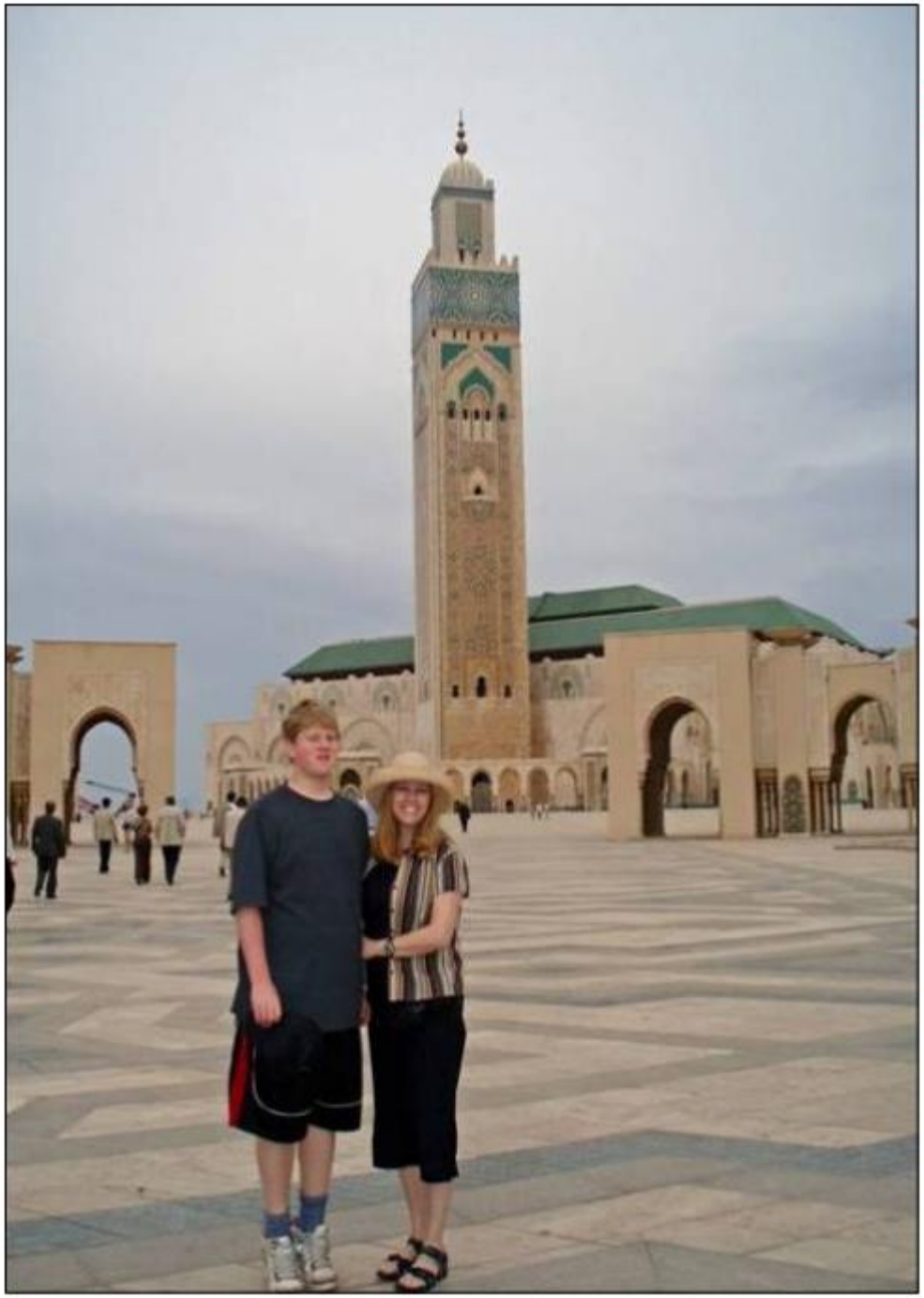
IF several deaths in workers in a particular job/location, then cause could be found
IF total Dose from all sources is large, then it is not low/protracted
IF max dose in a year is > 100 mGy, then this could be a cause

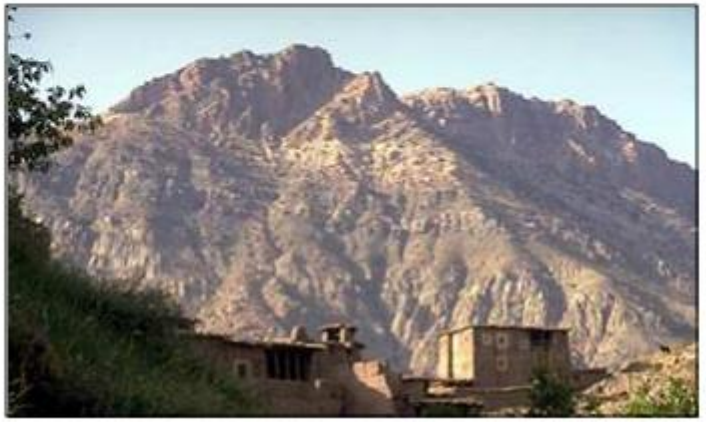
Effect of LNT

- LinearNoThreshold (LNT) says radiation is always harmful, no matter the dose
- Allowable amount of dose causes negligible harm; But it can still kill you or your child by cancer
- For Fukushima no detectable increase in cancer is expected, but people are terrified and diabetes, heart disease, smoking/drinking increase
- Thousands died in unnecessary evacuation, thousands more from shutdown of coal plants;
- Linear Threshold (LT) would correctly(?) estimate no harm to public

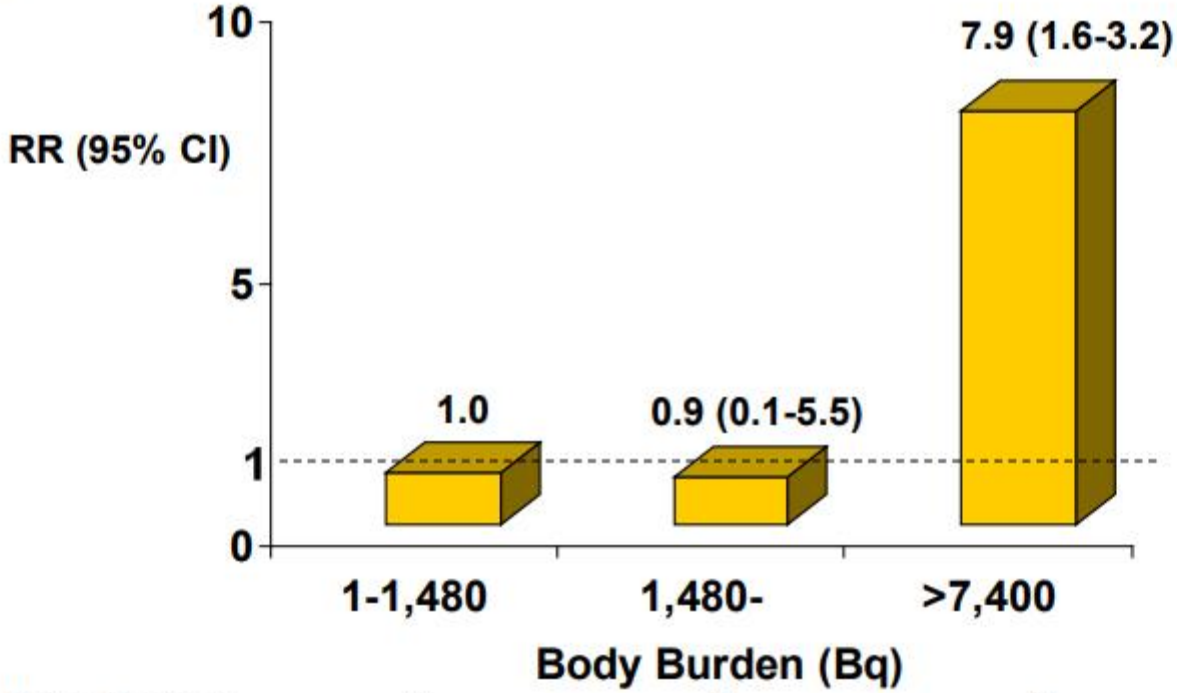


Some Uncertainties of Epidemiology…

- Effect primarily among immigrants, mainly from **Morocco**, not Israeli born (Ron, *Rad Res*, 1989)
- "Irradiation for tinea capitis was given to many Jews in **Morocco** prior to immigration…"(Modan, *JNCI* , 1980)
- **Genetic susceptibility** & family clustering (4 sisters thyroid disease)
- **Wiggle** could increase dose x 3
- Immigrants from Morocco came from Atlas Mt region, and **diets** deficient in stable iodine



Mayak - Plutonium - Bone



No. Bone Cancers	6	1	3
Person Years	162,540	15,614	4,410

Gilbert et al, *Radiat Res* 154:237, 2000

Alpha emitter, Bone threshold?
No leukemia excess. Shilnikova 2008

Sokolnikov et al, Int J Ca 2008– update_bone, liver, lung – same bone picture
Sokolnikov et al, PLos One, Feb 2015 – other than bone, liver, lung – low ERR/Sv
Hunter et al, Br J Ca PLos One, Oct 2013 – other than bone, liver, lung – no to low ERR/Sv