

# *Ionizing Radiation and Leukemia Among Japanese Atomic Bomb Survivors*

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Seminaire ASN

Risques de leucemies et exposition aux  
rayonnements ionisants

## *Atomic bombings of Hiroshima and Nagasaki*

### ❖ Hiroshima

- Unique  $U^{235}$  gun-type device
- 16 kt yield
- Hypocenter near city center



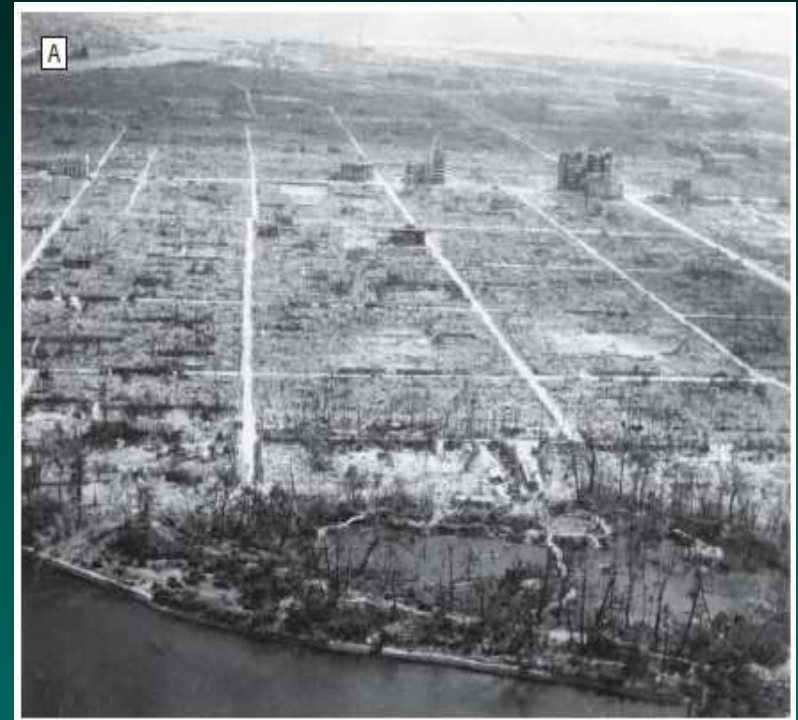
### ❖ Nagasaki

- Plutonium implosion device
- 21 kt yield
- Hypocenter in valley about 1.5 km from city center



## *Immediate effects of atomic bombings*

- ❖ Populations in areas near hypocenter decimated
  - Hiroshima 110,000 – 140,000 deaths
  - Nagasaki 70,000 deaths
  - >60% mortality within 1 km of hypocenter
- ❖ Cities largely destroyed
  - Wooden structures burned up to ~2.5 km from hypocenter
  - Blast effects apparent over similar distance



Hiroshima after the A-bombing.  
Photo: Paul Henshaw

## **Life Span Study of bomb survivors:**

**•86,611 people**

**who were residents of Hiroshima or Nagasaki at the times of the 1950 census, reported being in the cities at the time of the bombings and have radiation dose estimates**

- Radiation Dose Estimates

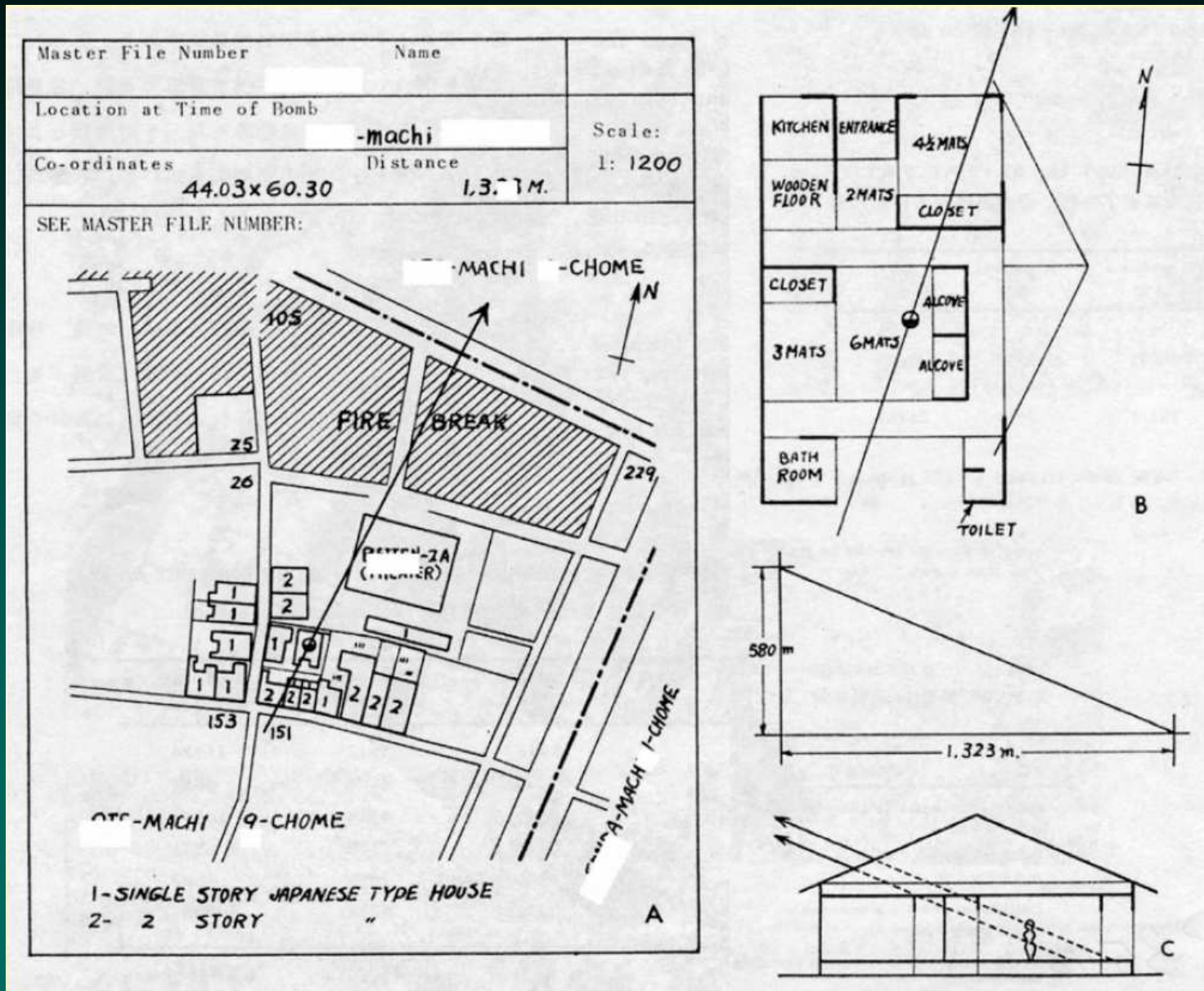
## Life Span Study of A-bomb Survivors

Location: specified as co-ordinates on US army maps

Shielding: detailed histories for most proximal survivors

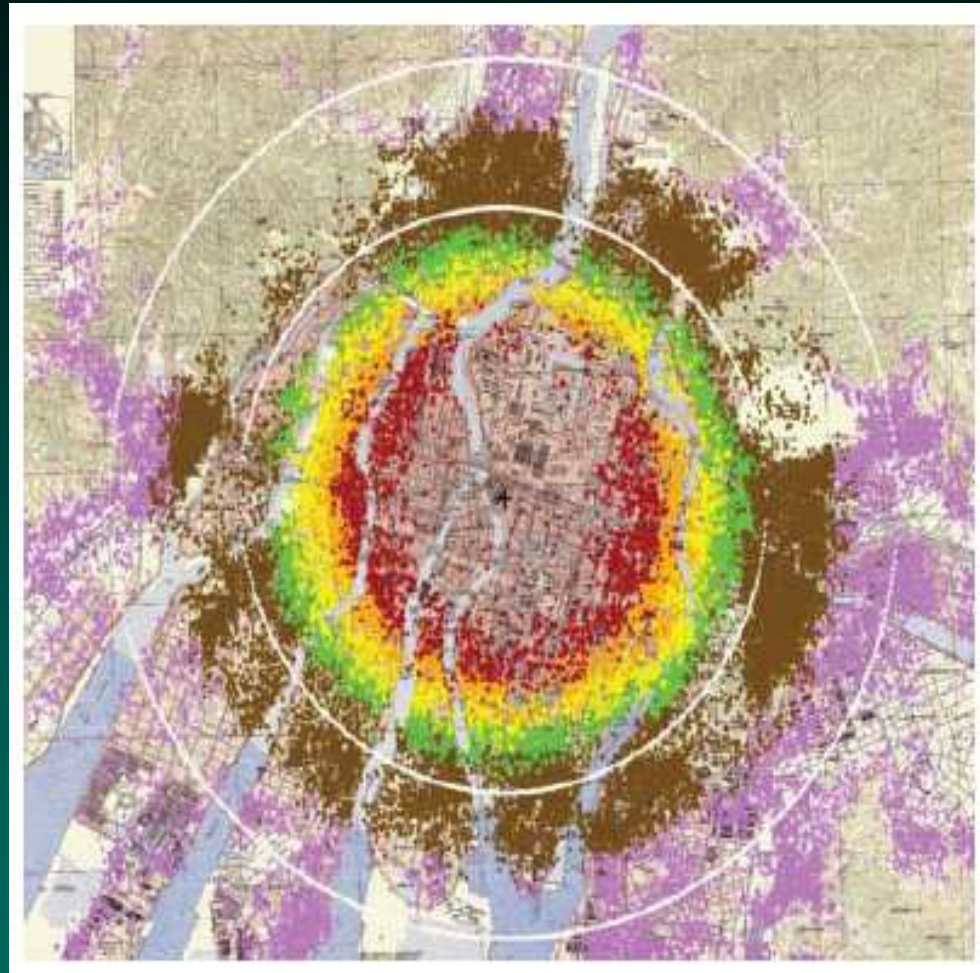


# Sample of the historical record





## *Map of A-bomb Survivors in Hiroshima.*



Location of survivors on a map of Hiroshima with color denoting estimated radiation doses.

(red=1000 mGy; orange=500-1000 mGy; yellow=200-500 mGy; brown=5-100 mGy; pink=5 mGy; gray=unknown). Rings represent 2- and 3-km distances from the hypocenter (+).

## Estimated radiation dose-leukemia mortality association.

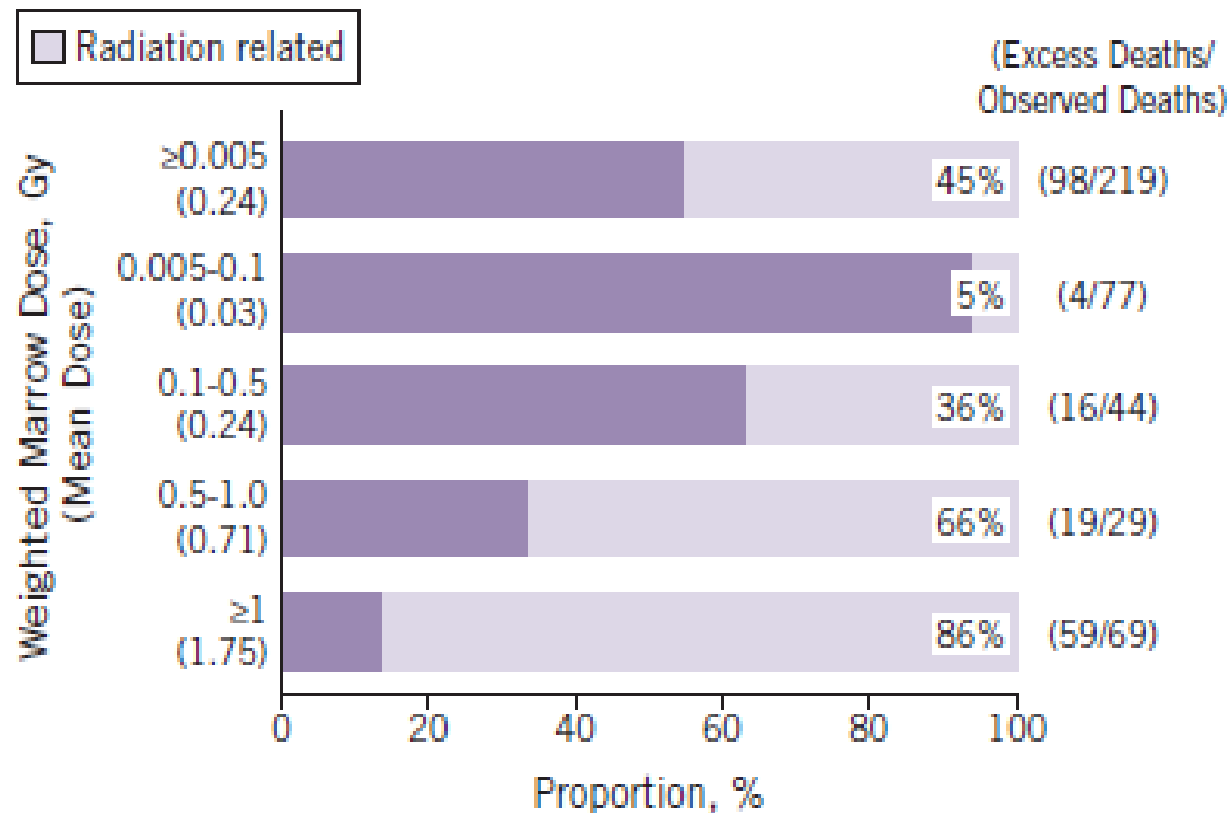
Dose (Gy)	<0.005	0.005-	0.1-	0.5-	1-	2+	Trend <sup>†</sup>
Rate Ratio	1.	1.0	1.4	3.3	6.7	17.3	4.7
90% CI	ref.	0.7, 1.5	0.9, 2.1	2.1, 5.1	4.4, 10.4	11.2, 26.7	3.5, 6.4
Observed	99	73	43	29	33	33	310

<sup>†</sup> based on a linear ERR model without effect modification of the ERR( $d$ ) =  $\beta d$

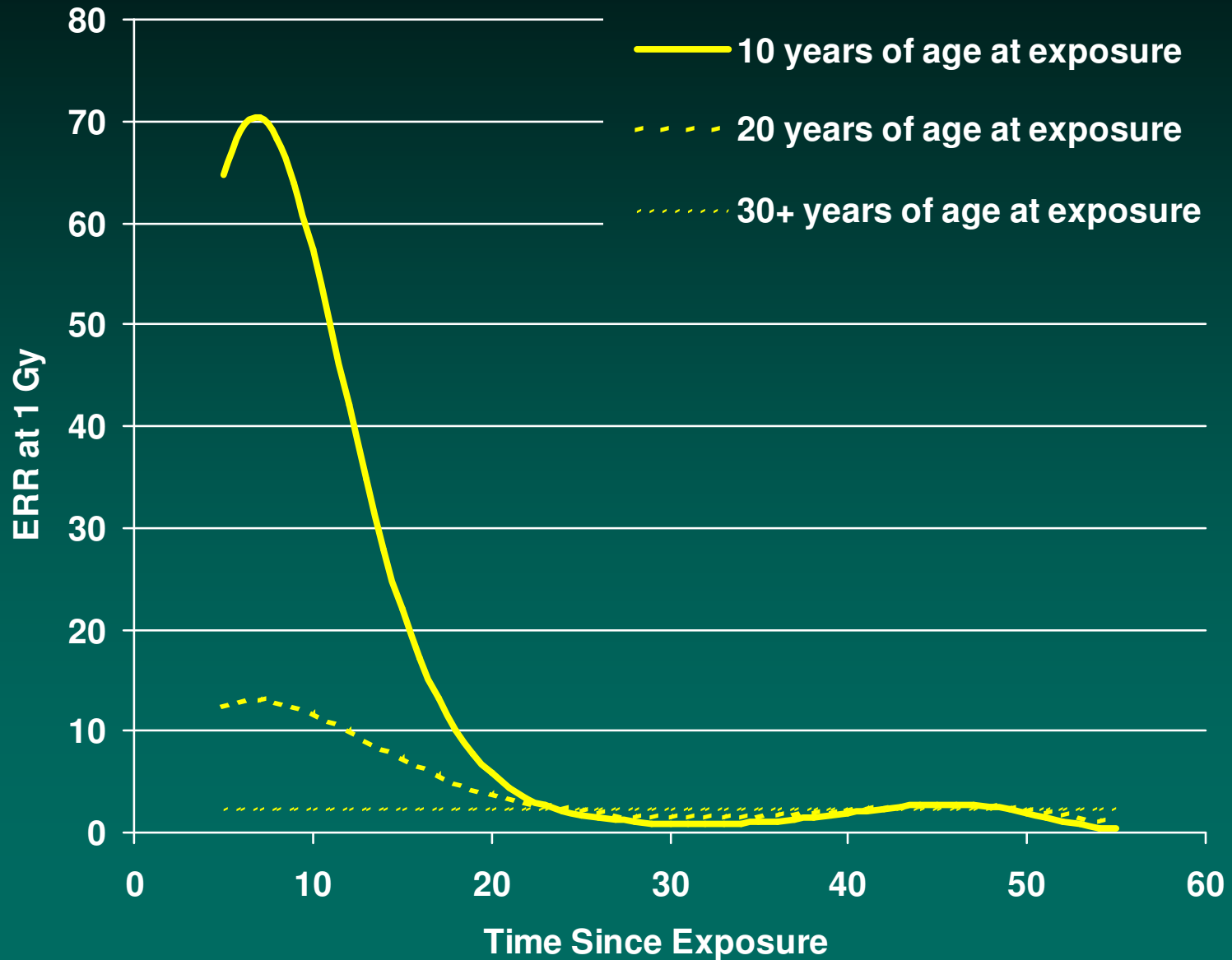


## ❖ Long term excess deaths: Leukemia

### Estimated proportion (attributable fraction) of radiation-related leukemia deaths by radiation dose (1950-2002)



# Predicted Excess Relative Risk of Leukemia (all types) by age at exposure and time since exposure.



## *Lessons from Hiroshima and Nagasaki*

**Leukemia mortality is associated with radiation dose**

**The excess relative risk of leukemia death declines with time-since-exposure**

**The excess fraction of leukemia was greatest among survivors <10 years old at time of bombing, and has diminished (but not disappeared) in the most recent decade of observation .**