

Introduction to the Radiation Effects Research Foundation: 75 Years of Studying the Health Effects of the Atomic Bombs

**Robert Ullrich, Ph.D.
Vice Chair and Chief of Research
Radiation Effects Research Foundation**



Research Begins...

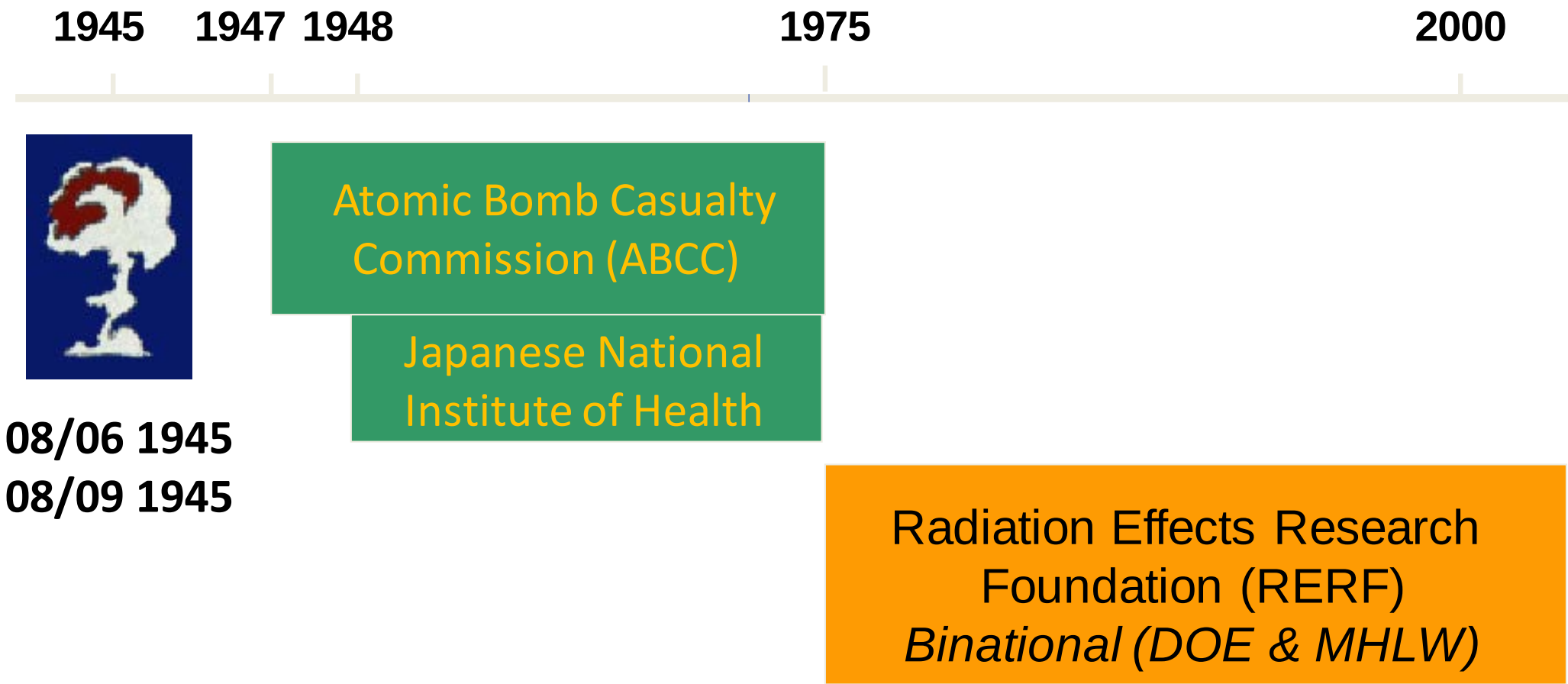
- American scientists "The Joint Commission" began to arrive in September, 1945
- Worked together with Japanese researchers already in the field
- Primarily interested in acute effects after the bombing
 - Damage by distance
 - Death rates by distance
 - Frequency and nature of early effects

Recommendations

- Study is 'beyond the scope...' of military researchers
- Long-range study of the medical and biological effects...
- Approved by President Truman in November 1946
- Atomic Bomb Casualty Commission (ABCC) begins studies in 1947
- Cooperative research agency of the NAS & The Japanese National Institute of Health (formalized 1948)



Study History of Health Effects of Atomic Bomb Radiation

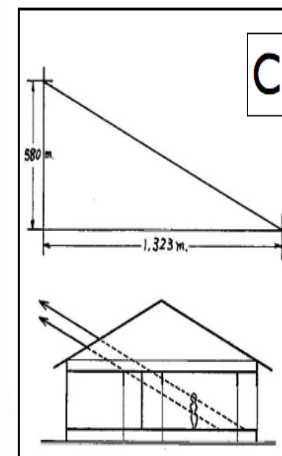
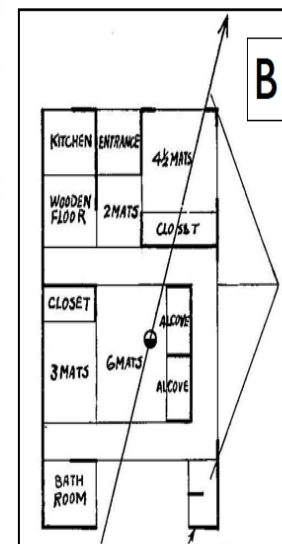
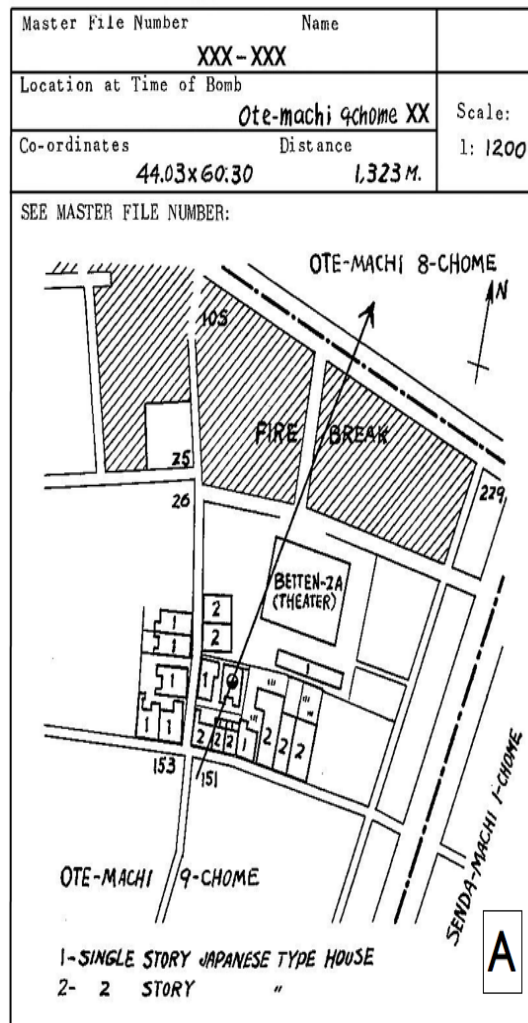


Current RERF Staffing

- 30 Researchers (6 Americans)
- 170 Support Staff
- Laboratories in Hiroshima and Nagasaki
- Departments:
 - Epidemiology
 - Statistics
 - Clinical Studies
 - Molecular Biosciences
 - Information Technology

Dosimetry

- Survivors were interviewed for shielding conditions at the time of the bombing
- Doses calculated from source term, distance to the survivor, terrain shielding, local shielding (may be an average), self (body) shielding
- 15 organ doses calculated



DOSE SYSTEMS

T65D

DS86



DS02 (DS02R1)

J45 Adult and Pediatric Phantoms

TABLE 1
Body Dimension of Japanese Children and Adults^a

Body dimension	Phantom age (year) and gender [male (M)/female (F)]						
	0 M/F	1 M/F	5 M/F	10 M/F	15 M/F	20 F	20 M
Height (cm)	49	74	102	126	150	152	162
Weight (kg)	2.8	8.5	16	25.5	44	50	54
Length of trunk, neck and head (cm)	32	46	59	70	82	84	88
Chest circumference (cm)	32	46	54	61	63	81	83

^a From RERF DS86, volume 1, chapter 8, Table 4 (2).

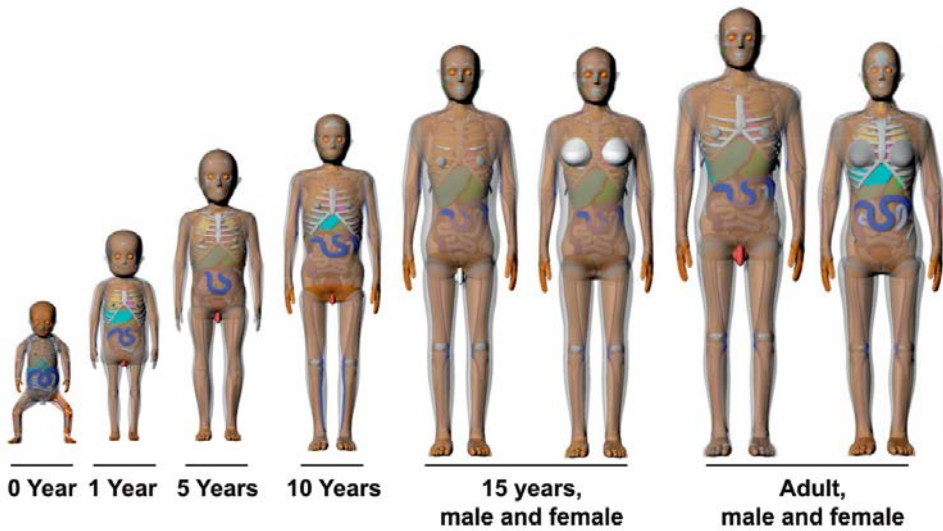


FIG. 1. Frontal view of the Japanese children and adult J45 hybrid phantom series.

RADIATION RESEARCH **191**, 369–379 (2019)
Dosimetric Impact of a New Computational Voxel Phantom Series for the
Japanese Atomic Bomb Survivors: Children and Adults

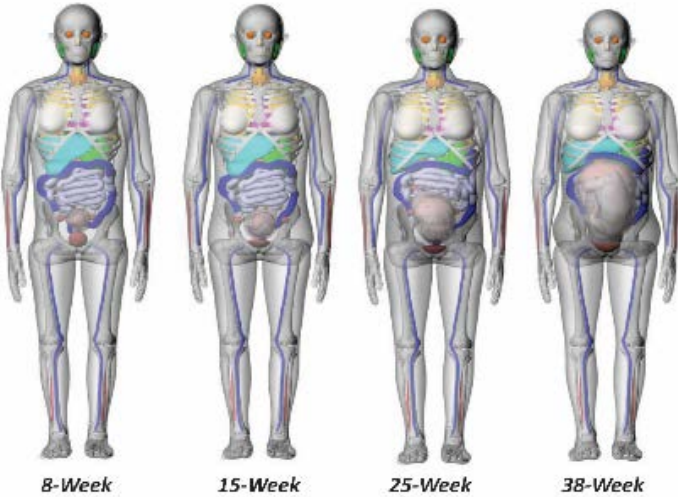
Keith Griffin,^a Colin Paulbeck,^b Wesley Bolch,^b Harry Cullings,^c Stephen Egbert,^{d,1} Sachiyo Funamoto,^e Tatsuhiko Sato,^e Akira Endo,^e Nolan Hertel^f and Choonsik Lee^{a,2}

J45 Pregnant Female Series

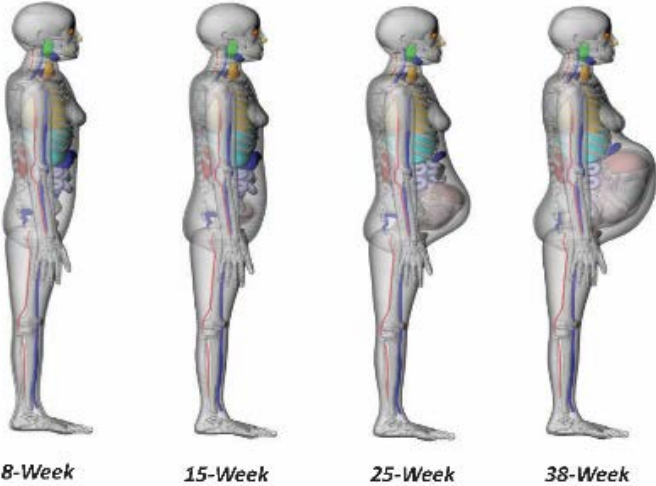
Modeling Parameter	Computational Phantoms / Gestational Age PC				
	Non-Pregnant Female	8-weeks	15-weeks	25-weeks	38-weeks
Standing Height (cm)	152	Same	Same	Same	Same
Sitting Height (cm)	84	Same	Same	Same	Same
UF/NCI Fetal Mass (g)		3.58	146.3	988.3	3299.4
J45 Fetal Mass (g)		3.04	124.2	838.7	2800.0
Ratio - J45 to UF/NCI		0.849	0.849	0.849	0.849
UF/NCI Total Mass (kg)	59.6	60.1	61.9	65.8	72.1
J45 Total Mass (kg)	50.0	50.4	51.9	55.2	60.5
Ratio - J45 to UF/NCI	0.839	0.839	0.838	0.839	0.839

Phantom	8-Week	15-Week	25-Week	38-Week
Maternal Circumference (cm)	78.3	88.2	93.9	98.1
Maternal AP Thickness (cm)	20.3	23.2	29.6	31.9
Fetal Abdominal Depth (cm)	6.7	7.9	8.2	9.3
Fetal Skull depth (cm)	7.3	11.1	15.3	17.9

A

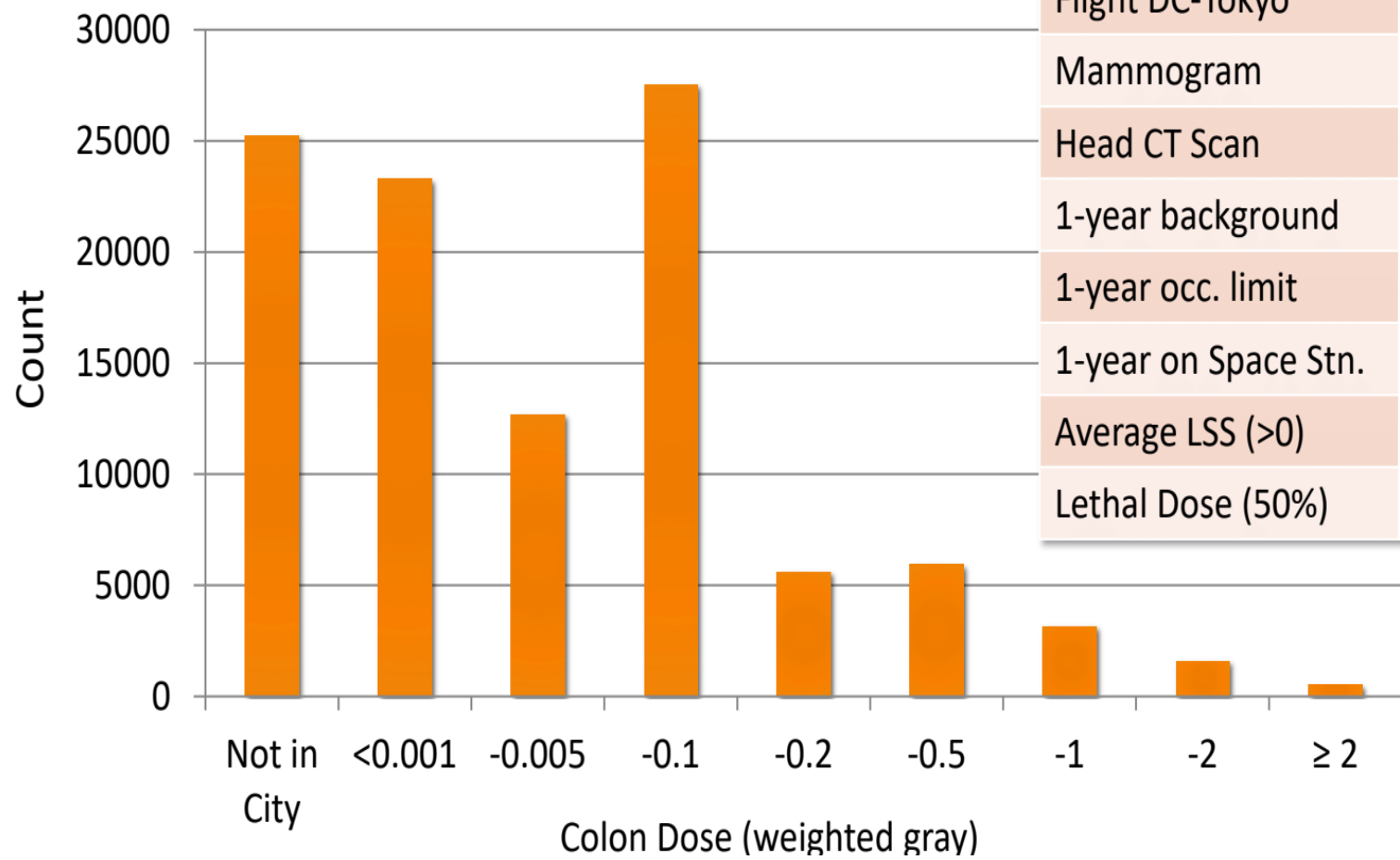


B



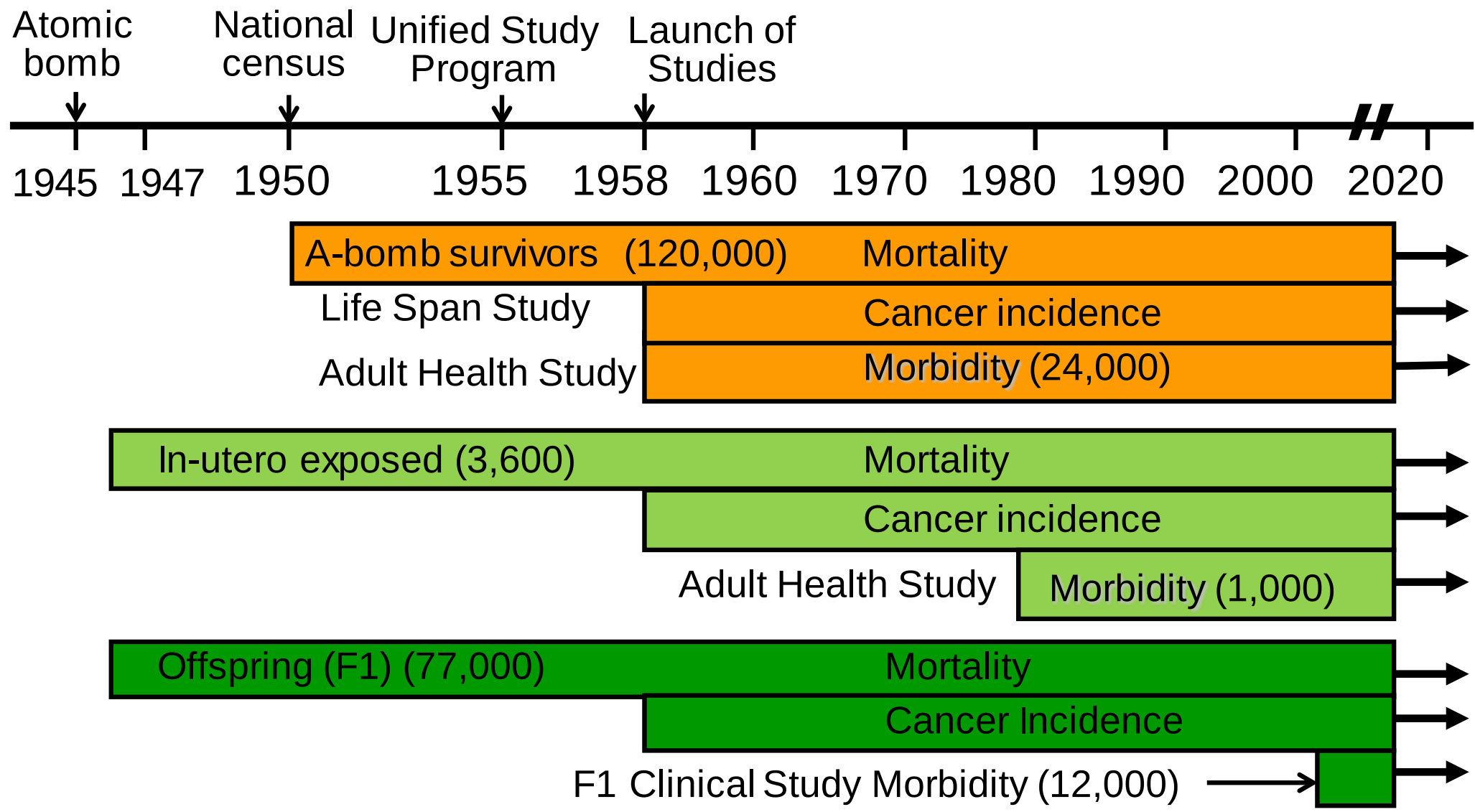
Life Span Study Dose Distribution

n=120,321



	Dose (gray)	Dose (mGy)
Flight DC-Tokyo	0.00005	0.05
Mammogram	0.0004	0.4
Head CT Scan	0.002	2
1-year background	0.005	5
1-year occ. limit	0.02	20
1-year on Space Stn.	0.17	170
Average LSS (>0)	0.20	200
Lethal Dose (50%)	4	4000

Epidemiological/ Clinical Data & Biosamples



Accumulation of epi/clinical data and biosamples

Current Status

Life Span Study (date)

Average Age 80

% Alive 23%

(70% 10 or less ATB)

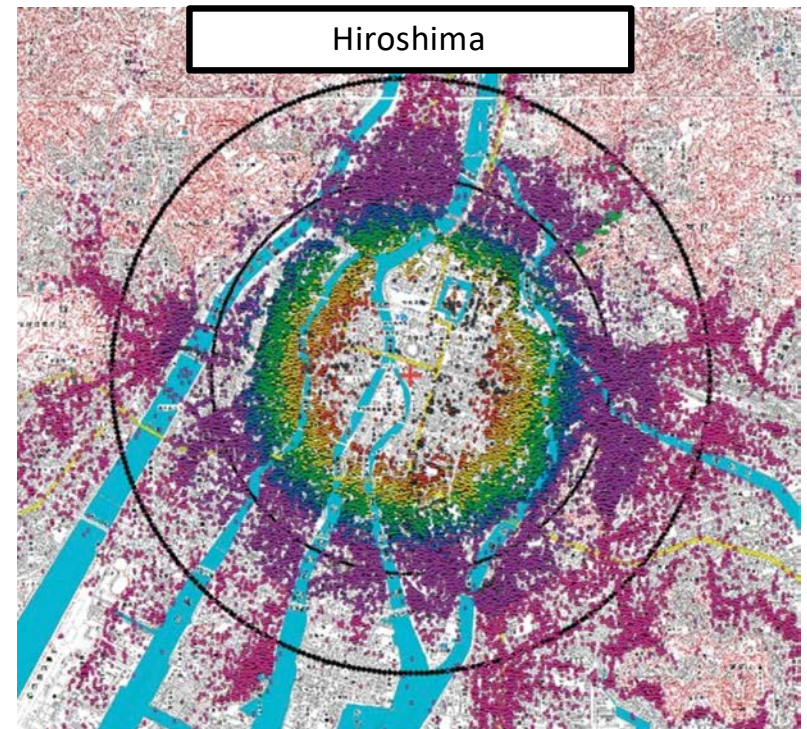
F1 Cohort (date)

Average Age 63

% Alive 87%

Advantages of Study

- Well-defined doses
- Non-selectively exposed population with rapidly decreasing doses by distance
- Little chance for bias or confounding by major cancer risk factors
- Highly significant risks by dose for all solid cancers in aggregate



Cullings, et al. *Health Physics*, 2017;112:46-97

Cancer

Radiation and Cancer

Risks, Modifying Factors, and Mechanisms

Non-Cancer

Radiation and Cardiovascular Disease Risks, Characterization, and Mechanisms

F1 Studies--Background

- Prior to the atomic bombings, plant and animal experiments had shown that ionizing radiation caused mutations that were passed to progeny
- Hereditary effects after radiation exposure among humans was unknown—and was a major concern
- Therefore, one of ABCC's first major studies was to investigate genetic effects among the children of the survivors (F1 Cohort)

Genetic Studies in the Offspring of A-Bomb Survivors

<u>Effects Examined</u>	<u>No. of individuals</u>
Birth Defects (UPO)*	72,000 (1948-1954)*
Sex Ratio	140,000 (1948-1966)
F1 Clinical Studies	10,000 (2002-on going)
F1 Mortality Studies	77,000 (1946-on going)
Chromosome Aberrations	16,000 (1967-1985)
Biochemical Tests	23,000 (1975-1984)
Sequencing**	~1,000 families (trios)

*Reanalysis of UPO ongoing

****PLANNED**

Genetic effects in offspring observed in a mouse model after parental exposure suggest effects are lower than predicted from mouse 7 locus studies

(Sato, et al., *Scientific Reports*, 2020)

Frequency of F1 Offspring by Parental Dose

(Individual offspring are counted even if within same family)

Variable		Mother DS02R1 weighted dose				
		NIC & < 0.01Gy	0.01+ Gy	1.0+ Gy	2.0+ Gy	Total
Father DS02R1 weighted dose	NIC & < 0.01Gy	618	320	94	9	1041
	0.01+ Gy	239	57	5	2	303
	1.0+ Gy	96	16	4	0	116
	2.0+ Gy	58	4	2	0	64
	Total	1011	397	105	11	1524

Focus on 1434 with on-axis doses – i.e. not both parents exposed (**bold**)

Hiroshima Today

